JICA Research Institute

JICA-RI Working Paper

Research on Declining Fertility in East Asia

Continuing Global Fertility Convergence

Yoko Nakagaki

No. 195

October 2019

JICA Research Institute

JICA Research Institute

JICA Research Institute
10-5 Ichigaya Honmura-cho
Shinjuku-ku
Tokyo 162-8433 JAPAN
TEL: +81-3-3269-3374
FAX: +81-3-3269-2054

Continuing Global Fertility Convergence

Yoko Nakagaki*

Abstract

This study reexamines fertility convergence by extending Dorius (2008), who explored global fertility convergence with quinquennial data from 1955–2005. Using annual data for 187 countries in 1960–2017, this study examines global as well as regional fertility convergence from three angles: β-convergence, inequality indices, and standard deviation. β-convergence is defined as the greater rate of fertility decline in higher-fertility countries compared to lower-fertility countries. Inequality indices and standard deviation are used to examine fertility convergence in terms of the decline in inequality (σ-convergence).

This study confirms the finding of Dorius (2008) that global fertility convergence starts in the second half of the 1990s. Moreover, this study finds that global fertility convergence continues after 2005 until 2017. It comprehensively examines fertility convergence by region for the first time and finds that fertility convergence/divergence is predicted by the level of total fertility rate (TFR)† in 1960. In regions with a mean TFR of six or less in 1960 (Europe, East Asia and the Pacific, Central Asia, and the Americas), fertility has been converging in recent decades, while fertility convergence is not confirmed in regions with a mean TFR of over six in 1960 (the Middle East and North Africa, sub-Saharan Africa, and South Asia). The result is consistent with another finding of this study: that global fertility convergence is more clearly observed if conducting a β-convergence estimation with samples of TFR1960≦5.8.

Keywords: population, total fertility rates, world, region, convergence

* National Graduate Institute for Policy Studies (y-nakagaki@grips.ac.jp). This paper has been prepared as part of a JICA Research Institute project entitled “Research on Declining Fertility in East Asia.” The author is deeply grateful to the anonymous reviewers for their insightful comments.

† Total fertility rate (TFR) refers to the theoretical number of children that would be born to a woman during her lifetime if she experienced the age-specific fertility rates observed in a calendar year.

1. Introduction

The fertility transition refers to the substantial decline of fertility around the world. Bongaarts (2002) observed that, in the developed world, fertility was already low in the early 1950s and, after experiencing short-term baby booms, it decreased further. In the developing world, fertility decline in Asia and Latin America was rapid. In sub-Saharan Africa, the fertility transition started later, and the decline proceeded at a slower pace (Bongaart 2017). Wilson (2001) regarded the global fertility transition as "convergence" in the sense that most of the developing world had moved rapidly toward the developed world with regard to fertility between 1950 and 2000, even though the study identified a significant number of high fertility populations that remained in 2000. United Nations (2019a) observes that nearly half of all people globally live in a country or area where TFR is below 2.1, which is roughly the level required for populations with low mortality to have a growth rate of zero in the long run.

Theories focusing on fertility decline can be categorized into two groups. The first focuses on incentives for couples to limit their fertility as a result of "adaption" or "adjustment" to changes in social and economic conditions. These could include raising the opportunity cost of childrearing or increasing incentives on education for children. The other focuses on "diffusion," which refers to the process by which new ideas, behaviors, and attitudes spread within a population through a variety of mechanisms. Bryant (2007) carried out a study testing the relative importance of the two theories on fertility declines in Asia, Latin America, North Africa and West Asia, and sub-Saharan Africa in the second half of the 20th century. The study concluded that "adaption" matched the evidence better than was generally believed in the field of demography, though the study also found that 20% of Asia's overall fertility decline was due to the "diffusion" of new contraception technologies and new ideas about family limitation. Using French *Département*-level data from the late 19th century and assuming spatial dependence to be the proxy of diffusion, Murphy (2015) empirically confirmed that both

"adaption" and "diffusion" affect fertility. Those findings suggest that fertility in developing countries declines along with both socioeconomic development and diffusion of ideas. United Nations (2019a) exemplified multiple factors that have been affecting the fertility transition: reductions in child mortality, increased levels of education in particular for women and girls, increased urbanization, expanded access to reproductive health-care services including for family planning, and women's empowerment and growing labor force participation.

2. Empirical analysis of fertility convergence by Dorius (2008)

Dorius (2008) empirically examined global fertility convergence, employing approaches that were used to examine income distribution. Similar to other studies in this area, Dorius employed total fertility rate (TFR) – the theoretical number of children that would be born to a woman during her lifetime if she experienced the age-specific fertility rates observed in a calendar year – as a proxy of fertility.[1] The study also utilized quinquennial TFR data in 1955–2005 for 195 countries.[2] For all the estimations, population weights were introduced.

At first, the study tested β-convergence of fertility, which was defined as the greater rate of fertility decline in higher-fertility countries compared to lower-fertility countries. The approach was based on the idea of β-convergence of income, whereby the incomes of poor citizens grew faster than those of other groups (Sala-i-Martin 1996; 2006). The equation employed to examine β-convergence by Dorius (2008) is:

$$\frac{\ln\left(\frac{\mathrm{TFR_{jn}}}{\mathrm{TFR_{j0}}}\right)}{\mathrm{T}} = \alpha + \beta\left(\mathrm{TFR_{j0}}\right) + \mathrm{e_j} \qquad (1)$$

where ln, TFR, j, 0, n, T, α, β, and e stand for natural logarithm, TFR, country j, beginning period, final period, period, constant, convergence coefficient, and the error term. If the estimated

[1] It should be noted that the change in the timing of childbearing affects TFR, because TFR is defined as the aggregation of age-specific fertility rates in a year.

convergence coefficient is negative, it indicates fertility convergence (in the sense that decline of fertility is more obvious in higher-fertility countries). The study confirmed β-convergence of TFR between 1955 and 2005 (negative and statistically significant convergence coefficient), which indicated global fertility convergence. In addition, piecewise regression by the study found that global fertility convergence started only after 1995: among estimations for 1955–1965, 1965–1975, 1975–1985, and 1995–2005, the convergence coefficient was negative and statistically significant only for the estimation on 1995–2005. β-convergence of fertility was also confirmed by Feyrer, Sacerdote and Stern (2008) for 110 countries in 1970–2000, though the study identified some exceptional countries – mainly in sub-Saharan Africa – with persistent high fertility. Nakagaki (2018) also confirmed the negative relationship between the beginning of the period fertility and the change of fertility in 1990–2014 for East Asian countries.

The second approach by Dorius (2008) focused on the declining inequality of fertility. The framework was also similar to Sara-i-Martin (2006), who examined decline of income inequality (σ-convergence). Dorius (2008) tested the decline of fertility inequality using SD (standard deviation) of fertility as well as three inequality indices: the Gini coefficient, the mean log deviation (MLD), and the Theil index. For all of these, the bigger the indices are, the bigger the inequality is.[3] Concerning the use of the SD, it should be noted that the level of SD is dependent upon the mean of the variable. Therefore, the distribution of the variable can be judged as converging only if the standard deviation is decreasing faster relative to the mean (Dorius 2008). Regarding three inequality indices, the Gini index is more sensitive to change in the middle of the distribution, while the MLD and Theil are sensitive to change in the distribution at the bottom and top, respectively (Dorius 2008). The study found that SD was smaller in 2005 than in 1955, though it remained virtually unchanged until the mid-1980s, and

[2] The study derived the TFR data from the World Population Prospects (United Nations 2019b).
[3] Sara-i-Martin (2006) tested world income inequality through eight indices: the Gini coefficient, the Atkinson index with coefficient 0.5(1), the variance of log income, the ratio of the income of top 20(10) centile to bottom 20(10)centile, the mean log deviation, and the Theil index.

started declining after that. Concerning the inequality indices, all three suggested an increasing inequality of fertility from 1955 to 1995, which started declining only after 1995.

From the results, the study concluded that fertility did not converge but diverged until around 1995, and only after that did fertility start to converge globally. Moreover, Dorius (2008) focused on the greater increase of the Theil than MLD from 1955 to 1995, which suggested that fertility divergence in the period was more attributable to the delayed fertility decline in higher-fertility countries than the decline of fertility in lower-fertility countries. This observation was consistent with the varied paces and timings of fertility decline across developing countries in the second half of the 20th century, and *pre-decline rises* of fertility observed in most developing countries (Dyson and Murphy 1985; Casterline 2001). [4] Regarding fertility convergence from 1995, Dorius (2008) observed a greater decline of the MLD than the Theil in 1995–2005, which suggests that fertility convergence is mainly attributable to slowing and/or recovery of fertility in lower-fertility countries than decline of fertility in higher-fertility countries.

3. Purpose of this study

This study reexamines global fertility convergence following approaches by Dorius (2008). It employs the annual data of TFR up to 2017, which is expected to make it possible to analyze the time series change of the convergence/divergence situation clearly. In addition, this study examines fertility convergence by region. Given the closer economic and social relationships within the region, fertility convergence could happen at regional levels.

[4] Dyson and Murphy (1985) referred to four reasons for the pre-decline rise of fertility: increases in marriage, declines in the duration of breastfeeding, declines in postpartum abstinence, and decreases of disease-related sterility.

Population weights are introduced for all estimations in this study, which implicitly assumes that all persons are assigned the mean TFR for their country. Therefore, this study could not capture the within-country inequality but international inequality only.

Section 4 shows the dataset of this study and observes how population-weighted TFRs have been changing around the world and its regions. After examining global fertility convergence in Section 5, fertility convergence within regions is examined in Section 6. Section 7 provides some concluding comments.

4. Fertility decline according to regions

4.1 Dataset of this study

This study employs the annual data of TFR and total population in 1960–2017 for 187 countries from the World Development Indicators (World Bank 2019). In order to examine fertility convergence within regions, this study categorizes all countries into seven regions: East Asia and the Pacific, South Asia, Central Asia, the Middle East and North Africa, sub-Saharan Africa, Europe, and the Americas. This study also examines estimations on four sub-regions: East Asia (in East Asia and the Pacific), Eastern Europe and Western Europe (in Europe), and Latin America and the Caribbean (in the Americas).[5] All region groups are summarized in Table 1. Appendix 1 lists countries in the dataset.

[5] This study does not include a sub-group for North America because the sub-region would be composed of only two countries.

[Table 1] Summary of the dataset

Region	Year	TFR				Population		N of countries
		Mean	Max	Min	S.D.	(10thousand)	Share(%)	
World								
	1960	5.528	8.187	1.940	1.725	301,139	100.0	187
	2017	2.716	7.184	1.052	1.322	748,156	100.0	187
East Asia and the Pacific (E.Asia_Pac)								
	1960	5.981	7.651	2.001	1.205	102,927	34.2	31
	2017	2.415	5.391	1.052	0.996	229,061	30.6	31
East Asia (E.Asia)								
	1960	5.723	7.148	2.001	1.248	100,059	33.2	14
	2017	1.840	2.894	1.052	0.610	221,962	29.7	14
South Asia (S.Asia)								
	1960	6.484	7.450	5.541	0.635	57,184	19.0	8
	2017	2.557	4.477	2.020	0.907	178,839	23.9	8
Central Asia (C.Asia)								
	1960	5.885	6.590	4.562	0.865	13,269	0.8	5
	2017	2.867	3.313	2.455	0.319	51,625	1.0	5
Middle East and North Africa (MENA)								
	1960	6.637	7.687	3.620	1.098	100,059	4.4	20
	2017	2.526	4.309	1.370	0.769	221,962	6.9	20
Sub-Saharan Africa (Subsahara)								
	1960	6.580	8.187	4.384	0.693	22,715	7.5	46
	2017	4.504	7.184	1.440	1.094	105,594	14.1	46
Europe (Eur)								
	1960	2.966	6.489	1.940	0.979	60,757	20.2	41
	2017	1.593	1.986	1.234	0.181	75,358	10.1	41
Eastern Europe (E.Eur)								
	1960	3.090	6.489	1.940	1.238	28,092	9.3	19
	2017	1.588	1.986	1.234	0.176	33,071	4.4	19
Western Europe (W.Eur)								
	1960	2.822	4.290	2.170	0.549	32,665	10.8	22
	2017	1.600	1.920	1.338	0.191	42,287	5.7	22
Americas								
	1960	5.830	7.555	2.880	1.295	41,875	13.9	36
	2017	2.091	2.920	1.101	0.410	100,549	13.4	36
Latin America and the Caribbean (Latin)								
	1960	5.954	7.555	2.880	1.223	22,017	7.3	34
	2017	2.118	2.920	1.101	0.404	64,363	8.6	34

Notes: The mean and SD of TFR are **not** population weighted. All data is from the World Development Indicators (World Bank 2019).

4.2 Population-weighted TFR around the world

Figure 1 shows the population-weighted TFRs for 1960–2017 around the world and its regions. Figure 1.1 includes TFRs of the world and regions with a TFR1960 (TFR in 1960) of equal or less than six; Figure 1.2 includes TFRs of the world and sub-regions; Figure 1.3 includes TFRs of the world and regions with a TFR in 1960 of over six. In all figures, the solid line stands for the world TFR. The world TFR in the dataset period starts from 5.06 in 1960 and records its peak

at 5.16 in 1965, which might be due to the pre-decline rises of fertility.[6] After the peak TFR in 1965, world TFR has continued to decline, reaching 2.45 in 2017.

TFRs in regions included in Figure 1.1 started to decline by 1970. TFR in Europe stopped declining at the end of the 20th century and recovered slightly after that (dashed line). In 2017, the mean TFRs in those regions seem to converge in a narrower range in comparison with 1960.

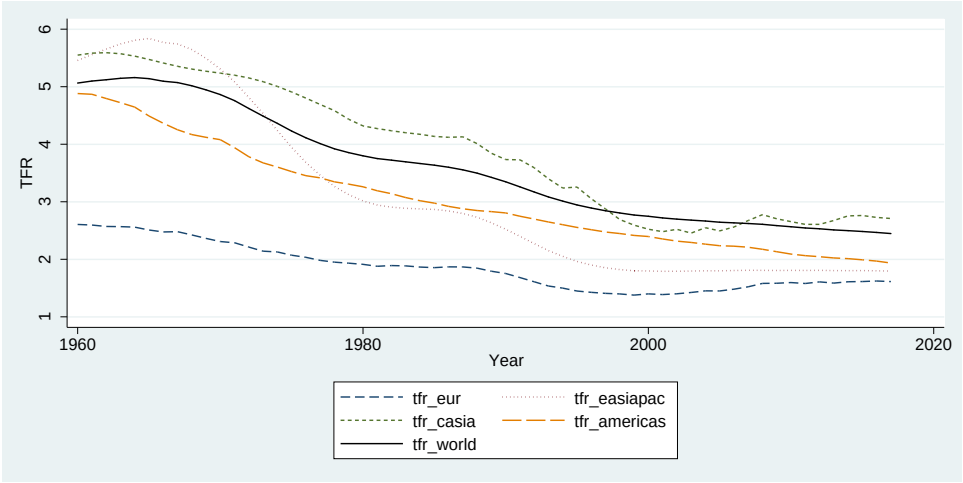
With regard to TFRs in sub-regions in Figure 1.2, TFR1960 of Latin America and the Caribbean (5.98, short dash and dot) is much higher than the Americas (4.88 long dash in Figure 1.1). The gap between these two TFRs is because of the much lower TFR in North America (TFR1960: 3.65 in the United States and 3.81 in Canada (Appendix 1)). Fertility decline in Eastern Europe (short dash) is lagged compared with that of Western Europe (long dash and dot). After the slowing of decline and a modest recovery in both sub-regions, TFRs in the two regions are quite similar in 2017.

Mean TFRs of regions in Figure 1.3 are more divergent in the wider range in 2017 than in 1960. This seems to be because TFR in sub-Saharan Africa is still nearly five in 2017, though it finally started declining in the 1980s.

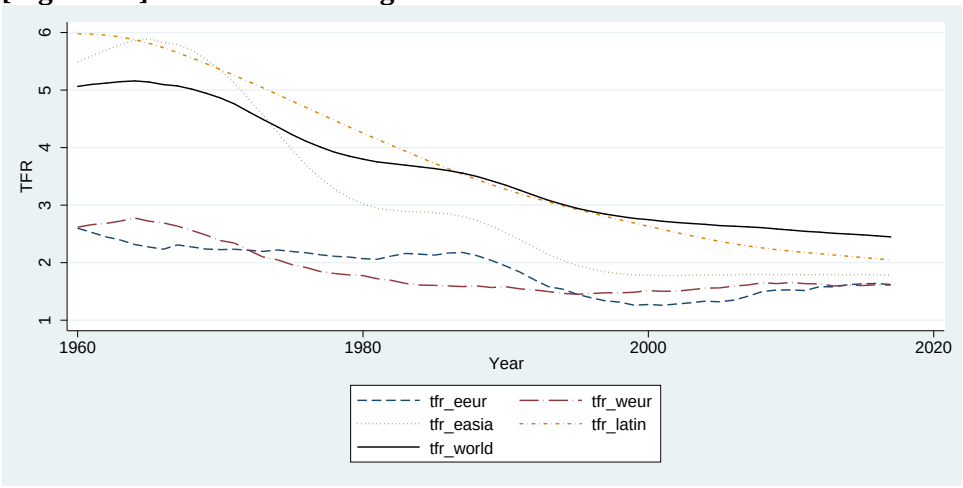
[6] The pre-decline rises are especially obvious in East Asia and the Pacific as indicated by the dotted line in Figure 1.1 (and East Asia (dotted line in Figure 1.2)).

[Figure 1] Population-weighted TFR by region

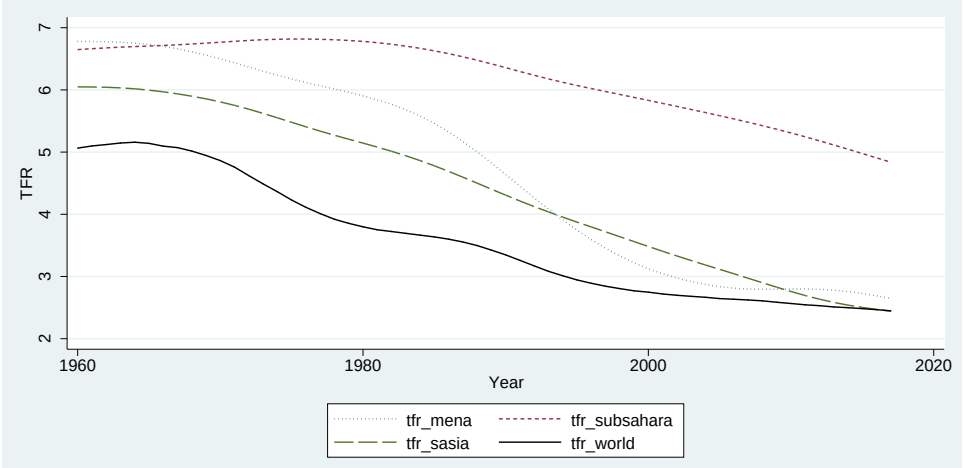
[Figure 1.1] World and regions with TFR1960≦6



[Figure 1.2] World and sub-regions



[Figure 1.3] World and regions with TFR1960>6



Note: TFRs in figures are **population weighted**.

5. Global fertility convergence

5.1 β-convergence of fertilities in the world

Figure 2.1 shows the result of β-convergence estimation of fertilities in the world between 1960 and 2017. The estimation is conducted by equation (1) of Dorius (2008) applying population weights. The result indicates a negative coefficient that is consistent with convergence. The scattered dots stand for TFR1960 of sample countries, which visually suggests that, if a country's TFR1960 is less than six, the country is more likely to be included in the convergence process expressed by the fitted line. On the other hand, most countries with a TFR1960 of six or over do not seem to be included in global fertility convergence.

To confirm the assumption, this study tests β-convergence estimations with samples of TFR1960 equal and below every 0.1 point between 2.1 and 6.5. Among them, the adjusted R^2 is highest for the estimation with samples TFR1960≦5.8 (Figure 2.2.1), and the estimated convergence coefficients for TFR1960 are stable at around -0.004 regardless of the maximum TFR1960 of between around three and six (Figure 2.2.2). The fitted line in Figure 2.2 stands for the estimation result for samples with TFR1960≦5.8. The line in Figure 2.2 is steeper sloped than that of the estimation with all samples (Figure 2.1) and the adjusted R^2 for Figure 2.2 reaches 0.848, which is higher than 0.201 of Figure 2.1. From the estimation, this study confirms that countries with a TFR1960 of below around six are more likely to be part of the convergence process than those with a TFR1960 of above around six.

This study also conducts piecewise regression on the world and regions for all possible ten-year-periods from 1960–1970 to 2007–2017. Figure 3 shows the results.[7] In the figure, if the dot for year X is below the horizontal line – which means that an estimated convergence coefficient is negative (Coef.<0) – and the dot is not tiny, β-convergence between year X and year (X+10) occurs. The patterns of the dots stand for the adjusted R^2. Tiny dots stand for

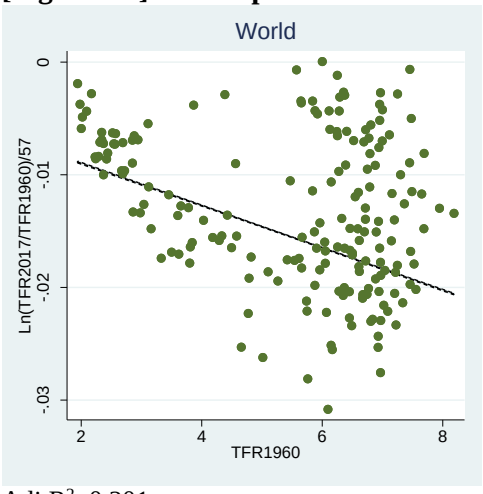
[7] The estimated convergence coefficients, P>|t|, and adjusted R^2 are summarized in Appendix 5.

adjusted R^2<0.1; hollow diamonds stand for 0.1≦adjusted R^2<0.3. As the Figure shows, convergence coefficients for the ten-year-period in the world are negative and statistically significant from the second half of the 1990s. Though all the adjusted R^2 for the period are less than 0.3, it could be concluded that β-convergence measured by ten-year-periods starts from the second half of the 1990s in the world.

Those results are consistent with Dorius (2008) in terms of β-convergence throughout the dataset period. In addition, this study finds that the β-convergence continues after 2005 until 2017 and that the adjusted R^2 for the estimations is highest when conducting estimations on samples with TFR1960 equal and under 5.8 (see Appendix 2.1 for a comparison of this study with Dorius (2008)).

[Figure 2] Estimation results on β-convergence of fertilities in the world for 1960–2017 (population weight is applied)

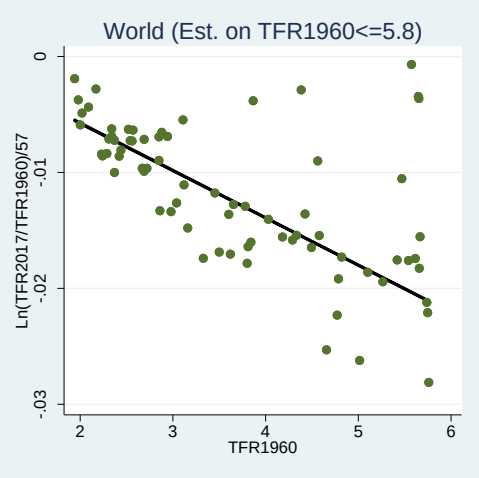
[Figure 2.1] All samples



Adj R^2: 0.201

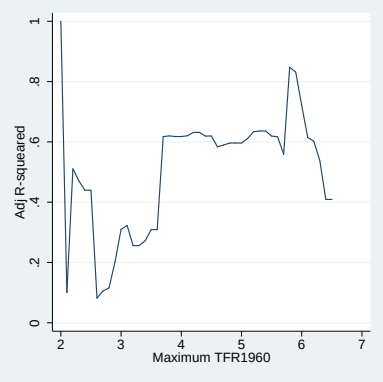
Notes: Figure 2.1 stands for the estimation result on β-convergence for 1960–2017 by equation (1). Estimated coefficients, S.E., and adjusted R^2 are shown in App4.1 in Appendix 4. Width of the lines stands for 95% confidence intervals.

[Figure 2.2] Countries with TFR1960≦5.8

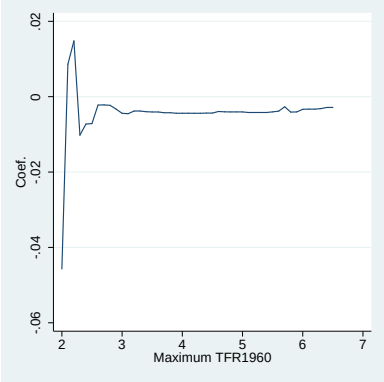


Adj R^2: 0.848

[Figure 2.2.1] Adjusted R^2 according to maximum TFR1960

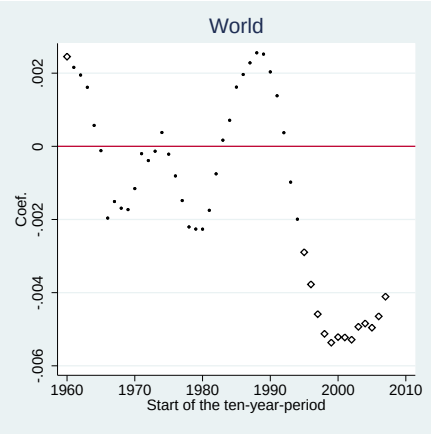


[Figure 2.2.2] Estimated coefficient according to maximum TFR1960



Notes: Figure 2.2 stands for the estimation result on β-convergence for 1960–2017 by equation (1) with sample of TFR1960≦5.8. Estimated coefficients, S.E., and adjusted R^2 are shown in App4.1.2 in Appendix 4. Width of the lines stands for 95% confidence intervals.
Figure 2.2.1–2 are the results of estimations to decide the upper limit of TFR1960, which seems to be included in the convergence estimation. From Figure 2.2.1, this study finds that the adjusted R^2 is highest when an estimation is conducted on countries with TFR1960 equal or below 5.8. From Figure 2.2.2, this study finds that the estimated coefficients are stable at around -0.004.

[Figure 3] Results for ten-year-period piecewise β-convergence of fertilities in the world from 1960–1970 to 2007–2017 (population weight is applied)



Notes: Figure 3 stands for the estimation result on ten-year-period piecewise β-convergence estimations from 1960–1970 to 2007–2017 by equation (1). "Coef." stands for estimated convergence coefficient. "Start of the ten-year-period" stands for the year of the first year in the ten-year-period: For instance, "2007" stands for 2007–2017. The patterns of the dots stand for the adjusted R^2. Tiny dots stand for adjusted R^2<0.1; hollow diamonds stand for 0.1≦ adjusted R^2<0.3. Estimated convergence coefficients, P>|t|, and adjusted R^2 are shown in Appendix 5.

5.2 σ-convergence of fertilities in the world

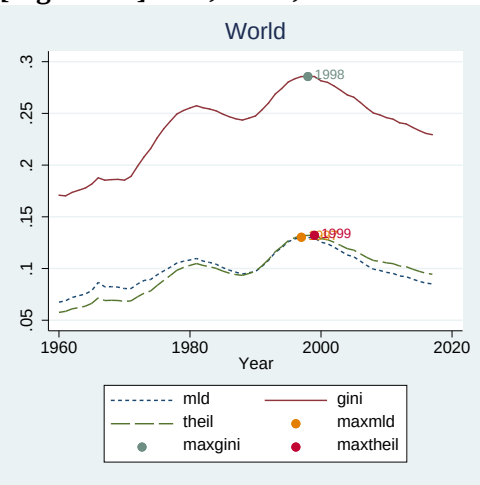
Figure 4 summarizes the results of σ-convergence of fertility. Figure 4.1 shows three inequality indices of TFRs: the Gini coefficient, MLD, and Theil index. All inequality indices are highest in the second half of the 1990s and they decline after that, which suggests that world fertility diverges from the 1960s and it converges from the second half of the 1990s. What should be noted is that the Theil increases more than the MLD in the divergence phase, while the MLD decreases more than the Theil in the convergence phase. As the MLD/Theil is more sensitive to the change at the distribution at the bottom/top, the divergence of TFR until the second half of the 1990s is more attributable to the persistent high fertility and/or the pre-decline rise in higher-fertility countries than the decline in fertility in lower-fertility countries. On the other hand, the convergence of TFR from the second half of the 1990s is more attributable to the slowing and/or the recovery of fertility in lower-fertility countries than the decline in fertility in higher-fertility countries. In comparison with Dorius (2008), this study additionally confirms that the decline of the Gini, MLD, and Theil from the second half of the 1990s continues after 2005 until 2017 (see Appendix 2.2 for a comparison of this study with Dorius (2008)).

This study also examines the time-series changes in SD of cross-country data of TFR. In addition to SD itself, this study examines the ratio of SD to the mean of TFR (SDM), considering

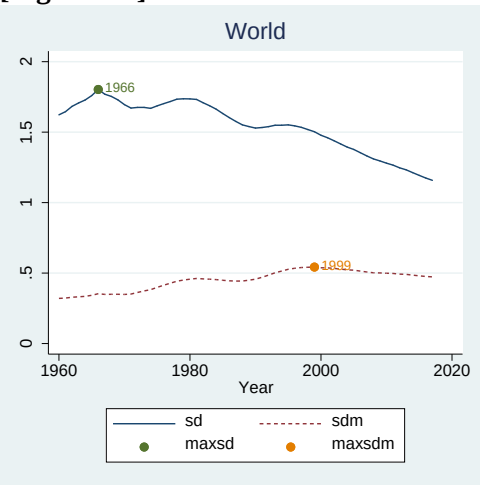
that SD depends on the mean of the variable. Figure 4.2 shows the results. SD is highest in the 1960s and started declining from the 1980s, while SDM is highest in the second half of the 1990s, which is consistent with the result from the Gini, MLD, and Theil.

[Figure 4] σ-convergence of fertilities in the world (population weight is applied)

[Figure 4.1] Gini, MLD, and Theil



[Figure 4.2] Standard deviation



Notes: In Figure 4.1 "mld," "gini," and "theil" stand for the mean log deviation, Gini coefficient, and Theil index, respectively. In Figure 4.2, "sd" stands for standard deviation; "sdm" stands for the ratio of standard deviation to the mean of TFR.

6. Fertility convergence within regions

6.1 β-convergence of fertilities within regions

Figure 5 shows the estimation results of β-convergence of fertilities within regions in 1960–2017. The patterns of fitted lines in the figures stand for the adjusted R^2 of the estimations: Solid lines mean adjusted $R^2 \geqq 3$; dotted lines stand for adjusted $R^2 < 1$. The width of the fitted lines stands for 95% confidence intervals.

Figure 5.1–4 show the results for regions with a population-weighted mean TFR1960 of equal or less than six, which are included in Figure 1.1.[8] For all the regions (Europe, East Asia and the Pacific, Central Asia, and the Americas), estimated convergence coefficients are

[8] Appendix 3.1 shows the results for sub-regions. The details of the results are summarized in Appendix 4.

negative and the adjusted R^2 are over 0.5, which indicates β-convergence. On the other hand, in regions with a population-weighted mean TFR1960 of over six (the Middle East and North Africa, sub-Saharan Africa, and South Asia), β-convergence is not confirmed (Figure 5.5–7).

Figure 6 shows the results of ten-year-period piecewise β-convergence of fertilities within regions. The patterns of the dots stand for the adjusted R^2, which is the same as Figure 3: Tiny dots stand for adjusted $R^2<0.1$; hollow diamonds stand for $0.1 \leqq$ adjusted $R^2<0.3$. In addition, bigger diamonds stand for adjusted $R^2 \geqq 0.3$.

Figures 6.1–4 show that fertility in regions with a mean TFR1960 of less than six (Europe, East Asia and the Pacific, Central Asia, and the Americas) continues to converge for decades, though the timing and the pace of convergence vary across regions. For Europe, all convergence coefficients are negative, which means fertility convergence throughout the period (Figure 6.1). In Western Europe, the regional fertility convergence is most clearly found in the 1970s (Appendix 3.2.2), while in Eastern Europe, the convergence coefficients are lowest in the 1990s (Appendix 3.2.1). For the Americas, the convergence coefficients are positive in the 1960s (Figure 6.4), and the coefficients are negative from the 1970s. The fertility divergence in the Americas of 1960s might be because TFRs in North America declined rapidly in the period (from 3.65 (1960) to 2.48 (1970) in the United States; from 3.81 (1960) to 2.26 (1970) in Canada (Appendix 1), while TFR in Latin America and the Caribbean are still over five (Figure 1.2).[9] In East Asia and the Pacific, and Central Asia (Figure 6.2 and 6.3), β-convergence is not observed for estimations starting in the 1980s but observed for estimations from the 1990s.

Regarding regions with a mean TFR1960 of over six (the Middle East and North Africa, sub-Saharan Africa, and South Asia), β-convergence is not confirmed in the dataset period (Figure 6.5–7). Positive coefficients are estimated for the 1960s in the Middle East and North Africa, and South Asia, and for the 1980s in sub-Saharan Africa. The period of positive

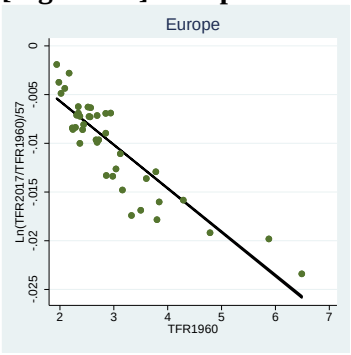
[9] Furthermore, Appendix 3.2.4 in Appendix 3.2 shows that estimated coefficients for Latin America and the Caribbean are negative all through the period, which suggests β-convergence.

coefficients, which means divergence, in each region seems to overlap with the onset of fertility decline in those regions (Figure 1.3).

In conclusion, in regions with a TFR1960 of equal or less than six (Europe, East Asia and the Pacific, Central Asia, and the Americas), β-convergence is observed for 1960–2017, and β-convergence for the ten-year-period is observed in recent decades. Regarding regions with a mean TFR1960 of over six (the Middle East and North Africa, sub-Saharan Africa, and South Asia), β-convergence is not confirmed.

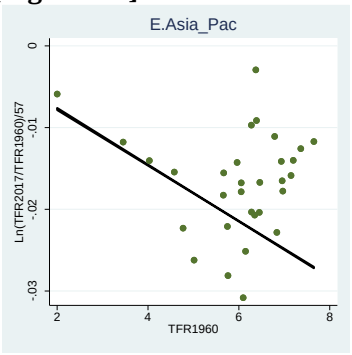
[Figure 5] Estimation results on β-convergence of fertilities within regions for 1960–2017 (population weight is applied)

[Figure 5.1] Europe



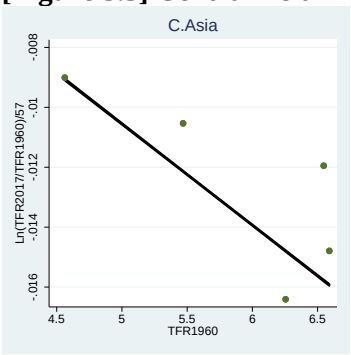
Adj R^2: 0.532

[Figure 5.2] East Asia and the Pacific



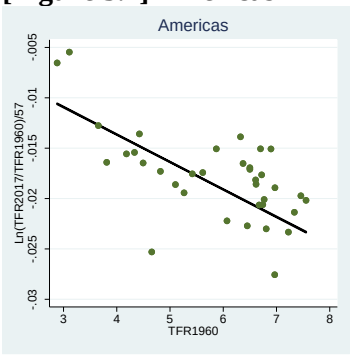
Adj R^2: 0.544

[Figure 5.3] Central Asia



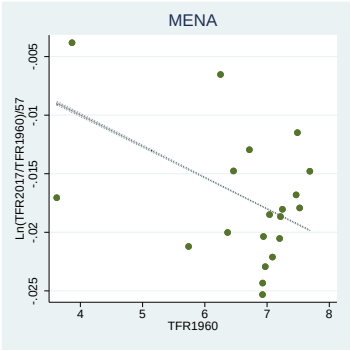
Adj R^2: 0.729

[Figure 5.4] Americas



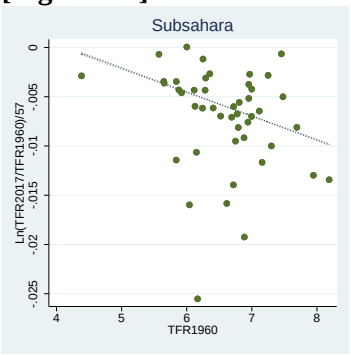
Adj R^2: 0.705

[Figure 5.5] Middle East and North Africa



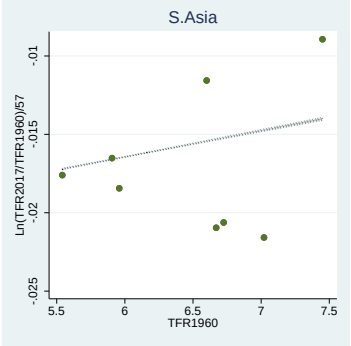
Adj R^2: 0.083

[Figure 5.6] Sub-Saharan Africa



Adj R^2: 0.097

[Figure 5.7] South Asia

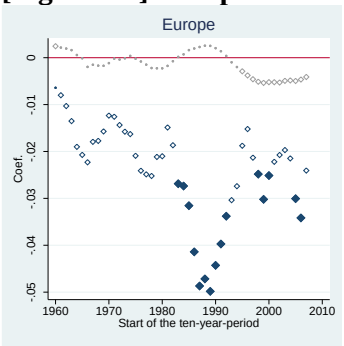


Adj R^2: 0.071

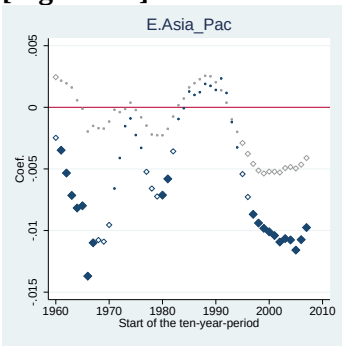
Notes: Figures stand for estimation results on β-convergence for 1960–2017 by equation (1). Results for sub-regions are in Appendix 3.1. Estimated coefficients, S.E., and adjusted R^2 are shown in Appendix 4. Solid lines stand for adjusted $R^2 \geqq 3$; Dotted lines stand for adjusted $R^2 < 1$. Width of the lines stands for 95% confidence intervals. Results of sub-regions are in Appendix 3.1.

[Figure 6] Results for ten-year-period piecewise β-convergence estimations on fertilities within regions from 1960–1970 to 2007–2017 (population weight is applied)

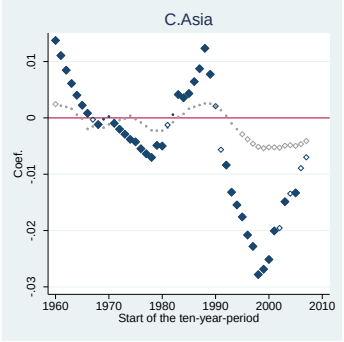
[Figure 6.1] Europe



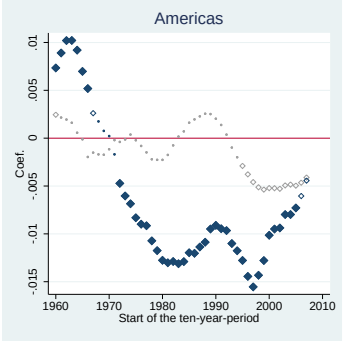
[Figure 6.2] East Asia and the Pacific



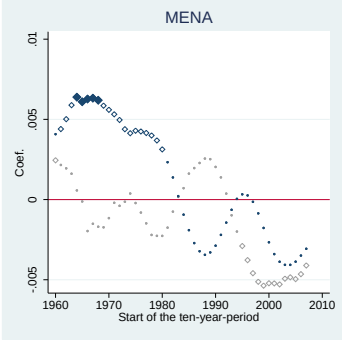
[Figure 6.3] Central Asia



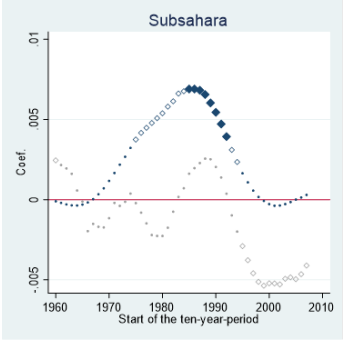
[Figure 6.4] Americas



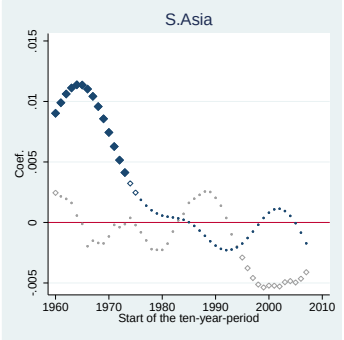
[Figure 6.5] Middle East and North Africa



[Figure 6.6] Sub-Saharan Africa



[Figure 6.7] South Asia



Notes: Figures stand for estimation results on ten-year-period piecewise β-convergence estimations from 1960–1970 to 2007–2017 by equation (1). Gray dots, which stand for the estimation results with all samples shown in Figure 3, are for the reference. "Coef." stands for estimated convergence coefficient. "Start of the ten-year-period" stands for the year of the first year in the ten-year-period: For instance, "2007" stands for 2007–2017. The patterns of the dots stand for the adjusted R^2. Tiny dots stand for adjusted $R^2<0.1$; hollow diamonds stand for $0.1 \leqq$ adjusted $R^2<0.3$; bigger diamonds stand for adjusted $R^2 \geqq 0.3$. Results for sub-regions are in Appendix 3.2. Estimated convergence coefficients, P>|t|, and adjusted R^2 are shown in Appendix 5.

6.2 σ-convergence of fertilities within regions

Three inequality indices reach their peaks by the 1980s for Europe (Figure 7.1), the Americas (Figure 7.4), and Central Asia (Figure 7.3), though the levels of indices are still high in the late 1990s in Central Asia. In East Asia and the Pacific (Figure 7.2), the Gini and Theil are highest in the late 1990s, while the MLD is highest in 1966. The irregular MLD peak in 1966 is due to the irregularly low TFR in Japan in the year.[10]

By contrast, three indices peaked in the early 2000s in the Middle East and North Africa (Figure 7.5), while they are highest in the 2010s in South Asia (Figure 7.7). However, in the two regions, the continued decline of those indices has not yet been observed. In sub-Saharan Africa, the indices have not reached their peaks (Figure 7.6).

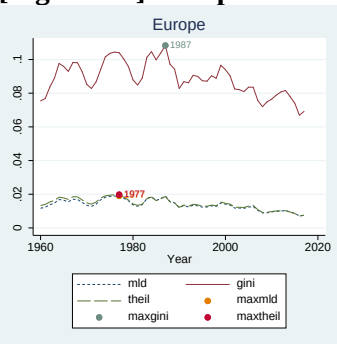
The result of SDM (Figure 8) is consistent with the results from three inequality indices. Regarding regions with TFR1960 below six, the peak of SDM in Europe (Figure 8.1) and the Americas (Figure 8.4) are in the 1970s; those in East Asia and the Pacific (Figure 8.2), and Central Asia (Figure 8.3) are in the 1990s. On the other hand, the peak of SDM in the Middle East and North Africa is in the early 2000s, while in South Asia the peak is in the 2010s. SDM has not yet reached its peak in sub-Saharan Africa.

From the results, it could be concluded that σ-convergence of fertilities starts by the second half of the 1990s in the regions with a TFR1960 of equal or below six, while σ-convergence of fertilities has not clearly been observed up to now in the regions with TFR1960 over six. The results are consistent with the results from β-convergence estimations.

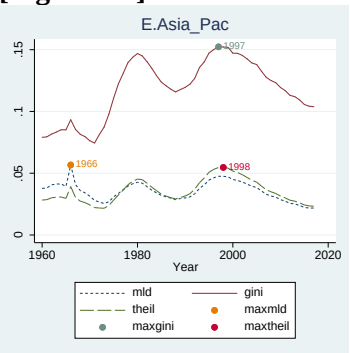
[10] In Japan, TFR was 2.139 in 1965, which was already the lowest among East Asia and the Pacific; this dropped to 1.58 in 1966 and recovered to 2.02 in 1967. Families in Japan were reluctant to give birth in 1966, as it was the year of the Fire Horse, renowned for disasters and the birth of women destined to kill their husbands.

[Figure 7] The Gini coefficient, MLD, and Theil index of fertilities within regions (population weight is applied)

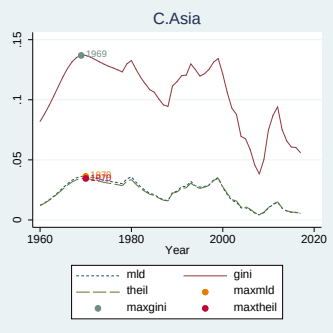
[Figure 7.1] Europe



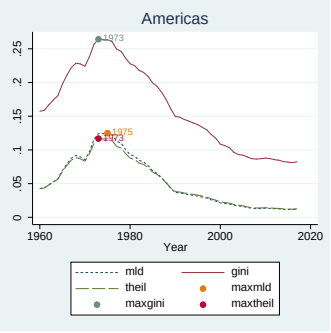
[Figure 7.2] East Asia and the Pacific



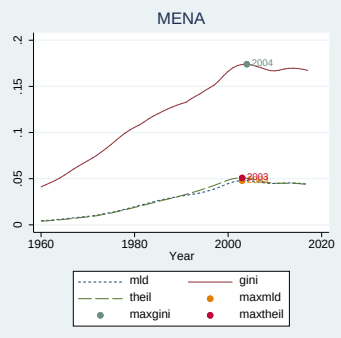
[Figure 7.3] Central Asia



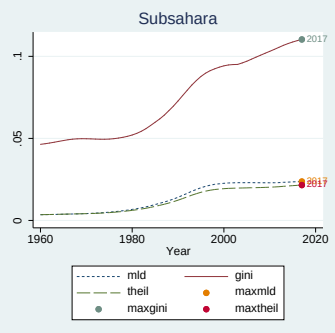
[Figure 7.4] Americas



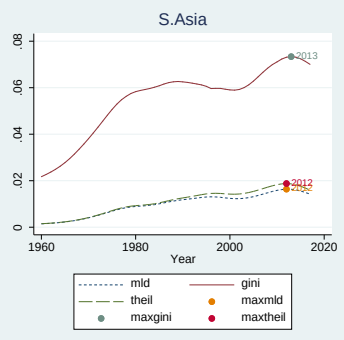
[Figure 7.5] Middle East and North Africa



[Figure 7.6] Sub-Saharan Africa



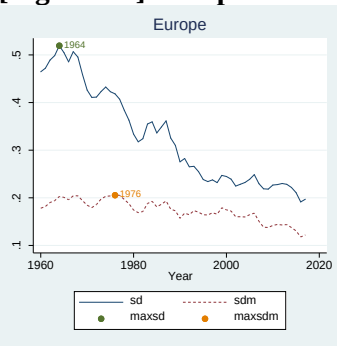
[Figure 7.7] South Asia



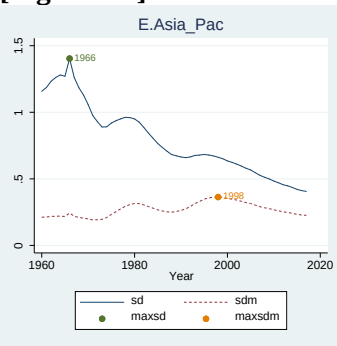
Notes: “mld,” “gini,” and “theil” stand for the mean log deviation, Gini coefficient, and Theil index, respectively. Results for sub-regions are in Appendix 3.3.

[Figure 8] Standard deviation and its ratio to the mean of fertilities within regions (population weight is applied)

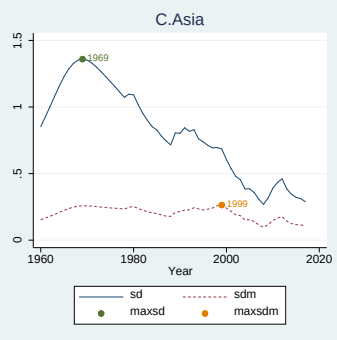
[Figure 8.1] Europe



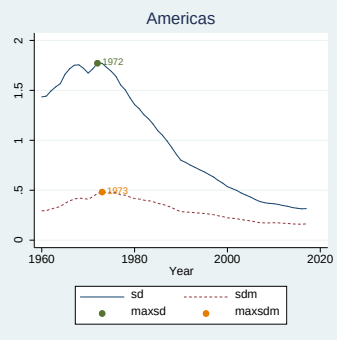
[Figure 8.2] East Asia and the Pacific



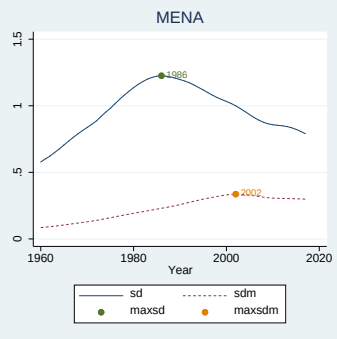
[Figure 8.3] Central Asia



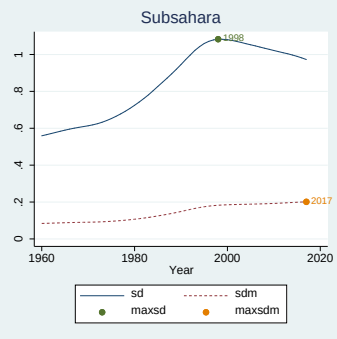
[Figure 8.4] Americas



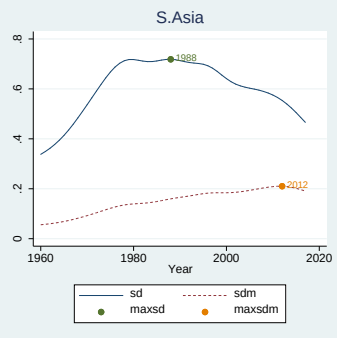
[Figure 8.5] Middle East and North Africa



[Figure 8.6] Sub-Saharan Africa



[Figure 8.7] South Asia



Notes: "sd" stands for standard deviation; "sdm" stands for the ratio of standard deviation to the mean of TFR. Results for sub-regions are in Appendix 3.4.

7. Conclusions

This study examines international fertility convergence by extending Dorius (2008) who examined global fertility convergence with quinquennial data for 1955–2005. Using annual data from 1960–2017, this study examines global as well as regional fertility convergence from three angles: β-convergence, inequality indices, and standard deviation.

This study finds that global fertility convergence which starts in the second half of the 1990s continues after 2005 until 2017 in terms of both β- and σ-convergence. In addition, this study finds that the adjusted R^2 for the β-convergence is the highest when conducting estimations on samples with TFR1960$\leqq$5.8. From the comparison of the MLD and Theil, this study also finds that the divergence of TFR until the 1980s is more attributable to the persistent high fertility and/or the pre-decline rise in higher-fertility countries than the decline in fertility in lower-fertility countries, while the convergence of TFR from the late 1990s is more attributable to the slowing and/or the recovery of fertility in lower-fertility countries than the decline in fertility in higher-fertility countries, which Dorius (2008) also pointed out.

Concerning fertility convergence within regions, this is the first study that examines fertility convergence in all regions of the world. This study finds that whether fertility converges or not in a region is predicted by the level of TFR1960. In regions with a mean TFR1960 of equal or less than six (Europe, East Asia and the Pacific, Central Asia, and the Americas), fertility convergence is observed in recent decades. By contrast, in regions with a mean TFR1960 of over six (the Middle East and North Africa, sub-Saharan Africa, and South Asia), fertility convergence is not clearly confirmed up to now. The results are consistent with another finding of this study: that β-convergence of global fertilities is more clearly observed if conducting an estimation with samples TFR1960$\leqq$5.8.

References

Bongaarts, J. 2002. “The End of the Fertility Transition in the Developed World.” *Population and Development Review* 28 (3): 419–43.

———. 2017. “Africa’s Unique Fertility Transition.” *Population and Development Review* 43 (S1): 39–58.

Bryant, J. 2007. “Theories of Fertility Decline and the Evidence from Development Indicators.” *Population and Development Review* 33 (1): 101–27.

Casterline, J. B. 2001. “The Pace of Fertility Transition: National Patterns in the Second Half of the Twentieth Century.” *Population and Development Review* 27, Supplement: Global Fertility Transition: 17–52.

Dorius, S. F. 2008. “Global Demographic Convergence? A Reconsideration of Changing Intercountry Inequality in Fertility.” *Population and Development Review* 34 (3): 519–37.

Dyson T. and M. Murphy. 1985. “The Onset of Fertility Transition.” *Population and Development Review* 11 (3): 399–440.

Feyrer, J., B. Sacerdote, and A. D. Stern. 2008. “Will the Stork Return to Europe and Japan? Understanding Fertility within Developed Nations.” *Journal of Economic Perspectives* 22 (3): 3–22.

Murphy, T. E. 2015. “Old Habits Die Hard (Sometimes): Can *Département* Heterogeneity Tell us Something about the French Fertility Decline?” *Journal of Economic Growth* 20 (2): 177–222.

Nakagaki. Y. 2018. “Fertility, Female Labor Participation and Income in East Asia.” *International Journal of Development Issues* 17 (1): 69–86.

Sala-i-Martin, X. X. 1996. “The Classical Approach to Convergence Analysis.” *The Economic Journal* 106 (437): 1019–36.

———. 2006. “The World Distribution of Income: Falling Poverty and ...Convergence, Period.” *The Quarterly Journal of Economics* 121 (2): 351–97.

United Nations. 2019a. *World Population Prospects 2019 Highlights*. New York: United Nations.

———. 2019b. *World Population Prospects* (Online Database). Accessed August 2019. https://population.un.org/wpp/Download/Standard/Fertility/

Wilson, C. 2001. “On the Scale of Global Demographic Convergence 1950–2000.” *Population and Development Review* 27 (1): 155–71.

World Bank. 2019. *World Development Indicators* (Online Database). Accessed January 2019. https://databank.worldbank.org/reports.aspx?source=world-development-indicators

[Appendix 1] List of countries

	Code	Countryname	TFR 1960	1970	1980	1990	2000	2010	2017	Population (2017, thousand)	Region / Sub-region
1	KOR	Korea, Rep.	6.095	4.53	2.82	1.57	1.467	1.226	1.052	51,466	EAP/E.Asia
2	PRI	Puerto Rico	4.657	3.146	2.607	2.219	2.049	1.624	1.101	3,325	Americas/Latin
3	HKG	Hong Kong SAR, China	5.014	3.284	2.047	1.272	1.032	1.127	1.125	7,392	EAP/E.Asia
4	SGP	Singapore	5.76	3.07	1.82	1.83	1.6	1.15	1.16	5,612	EAP/E.Asia
5	MDA	Moldova	3.328	2.582	2.481	2.414	1.435	1.274	1.234	3,549	Eur/E.Eur
6	CYP	Cyprus	3.5	2.61	2.354	2.411	1.716	1.424	1.338	1,180	Eur/W.Eur
7	MAC	Macao SAR, China	4.772	2.167	1.709	1.722	0.938	1.061	1.338	623	EAP/E.Asia
8	ITA	Italy	2.37	2.38	1.64	1.33	1.26	1.46	1.34	60,537	Eur/W.Eur
9	ESP	Spain	2.86	2.84	2.22	1.36	1.22	1.37	1.34	46,593	Eur/W.Eur
10	PRT	Portugal	3.16	3.01	2.25	1.56	1.55	1.39	1.36	10,300	Eur/W.Eur
11	MLT	Malta	3.62	2.03	1.99	2.04	1.68	1.36	1.37	468	MENA
12	UKR	Ukraine	2.24	2.09	1.95	1.844	1.11	1.443	1.374	44,831	Eur/E.Eur
13	BIH	Bosnia and Herzegovina	3.801	2.929	2.122	1.772	1.497	1.306	1.375	3,507	Eur/E.Eur
14	GRC	Greece	2.23	2.4	2.23	1.39	1.25	1.48	1.38	10,754	Eur/W.Eur
15	POL	Poland	2.98	2.2	2.28	2.06	1.37	1.41	1.39	37,975	Eur/E.Eur
16	HRV	Croatia	2.288	1.979	1.888	1.63	1.39	1.55	1.42	4,125	Eur/E.Eur
17	JPN	Japan	2.001	2.135	1.75	1.54	1.359	1.39	1.43	126,786	EAP/E.Asia
18	MUS	Mauritius	6.167	3.952	2.672	2.32	1.99	1.57	1.44	1,265	Sub-Sahara
19	LCA	St. Lucia	6.967	6.101	4.703	3.399	2.202	1.538	1.448	179	Americas/Latin
20	THA	Thailand	6.147	5.595	3.392	2.113	1.671	1.547	1.467	69,038	EAP/E.Asia
21	SVK	Slovak Republic	3.04	2.41	2.32	2.09	1.3	1.43	1.48	5,439	Eur/E.Eur
22	CHI	Channel Islands	2.421	2.121	1.454	1.46	1.402	1.436	1.483	165	Eur/W.Eur
23	CAN	Canada	3.811	2.258	1.74	1.83	1.488	1.627	1.496	36,708	Americas
24	HUN	Hungary	2.02	1.98	1.91	1.87	1.32	1.25	1.53	9,788	Eur/E.Eur
25	AUT	Austria	2.69	2.29	1.65	1.46	1.36	1.44	1.53	8,798	Eur/W.Eur
26	CHE	Switzerland	2.44	2.1	1.55	1.58	1.5	1.52	1.54	8,451	Eur/W.Eur
27	BGR	Bulgaria	2.31	2.17	2.05	1.82	1.26	1.57	1.54	7,076	Eur/E.Eur
28	BLR	Belarus	2.67	2.31	2.03	1.913	1.317	1.494	1.541	9,498	Eur/E.Eur
29	MKD	North Macedonia	3.842	3.158	2.486	2.206	1.723	1.465	1.542	2,083	Eur/E.Eur
30	FIN	Finland	2.72	1.83	1.63	1.78	1.73	1.87	1.57	5,508	Eur/W.Eur
31	DEU	Germany	2.37	2.03	1.44	1.45	1.38	1.39	1.57	82,686	Eur/W.Eur
32	SVN	Slovenia	2.341	2.231	2.064	1.46	1.26	1.57	1.58	2,066	Eur/E.Eur
33	EST	Estonia	1.98	2.17	2.02	2.05	1.36	1.72	1.6	1,317	Eur/E.Eur
34	ARM	Armenia	4.786	3.199	2.51	2.544	1.648	1.693	1.604	2,930	Eur/E.Eur
35	CZE	Czech Republic	2.09	1.92	2.08	1.9	1.15	1.51	1.63	10,594	Eur/E.Eur
36	CHN	China	5.748	5.648	2.63	2.35	1.497	1.59	1.631	1,386,395	EAP/E.Asia
37	IRN	Iran, Islamic Rep.	6.927	6.44	6.481	4.818	2.211	1.765	1.636	81,163	MENA
38	ROU	Romania	2.34	2.89	2.43	1.83	1.31	1.59	1.64	19,584	Eur/E.Eur
39	MNE	Montenegro	3.603	2.737	2.243	2.078	1.875	1.767	1.658	622	Eur/E.Eur
40	NLD	Netherlands	3.12	2.57	1.6	1.62	1.72	1.79	1.66	17,131	Eur/W.Eur
41	BEL	Belgium	2.54	2.25	1.68	1.62	1.67	1.86	1.68	11,382	Eur/W.Eur
42	LTU	Lithuania	2.56	2.4	1.99	2.03	1.39	1.5	1.69	2,828	Eur/E.Eur
43	ALB	Albania	6.489	4.91	3.621	2.978	2.157	1.653	1.71	2,873	Eur/E.Eur
44	NOR	Norway	2.85	2.5	1.72	1.93	1.85	1.95	1.71	5,277	Eur/W.Eur
45	BRA	Brazil	6.07	5.009	4.068	2.909	2.3	1.805	1.711	209,288	Americas/Latin
46	LBN	Lebanon	5.739	4.948	3.997	3.002	2.225	1.614	1.713	6,082	MENA
47	CUB	Cuba	4.182	4.033	1.892	1.75	1.617	1.639	1.722	11,485	Americas/Latin
48	ARE	United Arab Emirates	6.929	6.655	5.505	4.454	2.644	1.869	1.731	9,400	MENA
49	TTO	Trinidad and Tobago	5.264	3.554	3.284	2.453	1.753	1.806	1.739	1,369	Americas/Latin
50	LVA	Latvia	1.94	1.96	1.86	2.02	1.25	1.36	1.74	1,942	Eur/E.Eur

[Appendix 1] continued 1

	Code	Countryname	TFR 1960	1970	1980	1990	2000	2010	2017	Population (2017, thousand)	Region / Sub-region
51	ISL	Iceland	4.29	2.81	2.48	2.3	2.08	2.2	1.74	343	Eur/W.Eur
52	BHS	Bahamas, The	4.495	3.531	2.989	2.639	2.071	1.865	1.758	395	Americas/Latin
53	RUS	Russian Federation	2.52	1.99	1.89	1.892	1.195	1.567	1.762	144,497	Eur/E.Eur
54	AUS	Australia	3.453	2.859	1.891	1.902	1.756	1.928	1.765	24,602	EAP
55	USA	United States	3.654	2.48	1.84	2.081	2.056	1.931	1.766	325,147	Americas
56	CHL	Chile	5.102	4.019	2.778	2.547	2.107	1.879	1.766	18,055	Americas/Latin
57	CRI	Costa Rica	6.451	4.611	3.588	3.172	2.373	1.922	1.768	4,906	Americas/Latin
58	DNK	Denmark	2.57	1.95	1.55	1.67	1.77	1.87	1.79	5,765	Eur/W.Eur
59	GBR	United Kingdom	2.69	2.44	1.9	1.83	1.64	1.92	1.79	66,023	Eur/W.Eur
60	ABW	Aruba	4.82	2.908	2.392	2.249	1.872	1.776	1.798	105	Americas/Latin
61	BRB	Barbados	4.333	3.113	2.004	1.74	1.744	1.781	1.799	286	Americas/Latin
62	NZL	New Zealand	4.03	3.158	2.03	2.18	1.98	2.17	1.81	4,794	EAP
63	IRL	Ireland	3.78	3.85	3.21	2.11	1.89	2.05	1.81	4,811	Eur/W.Eur
64	COL	Colombia	6.807	5.548	3.965	2.994	2.389	2.01	1.834	49,066	Americas/Latin
65	SWE	Sweden	2.17	1.92	1.68	2.13	1.54	1.98	1.85	10,058	Eur/W.Eur
66	BRN	Brunei Darussalam	6.836	5.719	4.067	3.291	2.218	1.838	1.861	429	EAP
67	QAT	Qatar	6.971	6.91	5.806	4.013	3.236	2.07	1.886	2,639	MENA
68	PRK	Korea, Dem. People's Rep.	4.579	4.315	2.773	2.289	1.987	1.979	1.899	25,491	EAP
69	AZE	Azerbaijan	5.878	5.018	3.497	2.74	2	1.92	1.9	9,854	Eur/E.Eur
70	VCT	St. Vincent and the Grenadine	7.224	6.014	3.985	2.956	2.379	2.07	1.911	110	Americas/Latin
71	FRA	France	2.85	2.55	1.85	1.77	1.89	2.03	1.92	67,106	Eur/W.Eur
72	VNM	Vietnam	6.348	6.465	5.046	3.553	2.01	1.946	1.95	95,541	EAP/E.Asia
73	NCL	New Caledonia	6.278	4.3	3.424	3.18	2.59	2.2	1.97	280	EAP
74	URY	Uruguay	2.88	2.902	2.726	2.52	2.242	2.078	1.984	3,457	Americas/Latin
75	GEO	Georgia	2.942	2.707	2.314	2.18	1.608	1.918	1.986	3,728	Eur/E.Eur
76	JAM	Jamaica	5.419	5.477	3.733	2.947	2.577	2.173	1.993	2,890	Americas/Latin
77	PYF	French Polynesia	5.658	5.057	3.989	3.401	2.463	2.11	1.997	283	EAP
78	BHR	Bahrain	7.087	6.501	4.916	3.732	2.795	2.164	2.009	1,493	MENA
79	MYS	Malaysia	6.45	5.014	4.068	3.554	2.784	2.149	2.019	31,624	EAP/E.Asia
80	BTN	Bhutan	6.67	6.671	6.553	5.639	3.604	2.382	2.02	808	S.Asia
81	LKA	Sri Lanka	5.541	4.342	3.408	2.483	2.241	2.203	2.032	21,444	S.Asia
82	TUR	Turkey	6.366	5.619	4.405	3.107	2.503	2.155	2.034	80,745	MENA
83	ATG	Antigua and Barbuda	4.425	3.684	2.115	2.061	2.316	2.13	2.04	102	Americas/Latin
84	MDV	Maldives	7.021	7.227	7.081	5.993	2.944	2.229	2.052	436	S.Asia
85	SLV	El Salvador	6.674	6.172	5.1	3.964	3.022	2.265	2.058	6,378	Americas/Latin
86	BGD	Bangladesh	6.725	6.947	6.359	4.494	3.17	2.328	2.076	164,670	S.Asia
87	VIR	Virgin Islands (U.S.)	5.615	5.167	3.138	2.954	2.06	2.3	2.08	107	Americas/Latin
88	NPL	Nepal	5.959	5.918	5.725	5.172	4.03	2.606	2.083	29,305	S.Asia
89	GRD	Grenada	6.743	4.604	4.251	3.842	2.582	2.24	2.083	108	Americas/Latin
90	MEX	Mexico	6.768	6.83	4.836	3.47	2.716	2.341	2.153	129,163	Americas/Latin
91	NIC	Nicaragua	7.336	6.892	6.132	4.597	3.083	2.428	2.171	6,218	Americas/Latin
92	TUN	Tunisia	6.942	6.705	5.243	3.476	2.142	2.144	2.175	11,532	MENA
93	MMR	Myanmar	6.051	5.964	4.92	3.455	2.914	2.41	2.187	53,371	EAP/E.Asia
94	LBY	Libya	7.202	8.132	7.219	4.966	2.856	2.412	2.235	6,375	MENA
95	ARG	Argentina	3.109	3.073	3.325	2.989	2.561	2.37	2.277	44,271	Americas/Latin
96	VEN	Venezuela, RB	6.616	5.404	4.199	3.448	2.822	2.472	2.294	31,977	Americas/Latin
97	CPV	Cabo Verde	6.885	6.935	6.375	5.307	3.762	2.666	2.299	546	Sub-Sahara
98	IND	India	5.906	5.587	4.827	4.045	3.311	2.601	2.304	1,339,180	S.Asia
99	GUM	Guam	6.052	4.372	3.248	3.013	2.824	2.472	2.328	164	EAP
100	IDN	Indonesia	5.666	5.474	4.43	3.122	2.512	2.483	2.336	263,991	EAP/E.Asia

[Appendix 1] continued 2

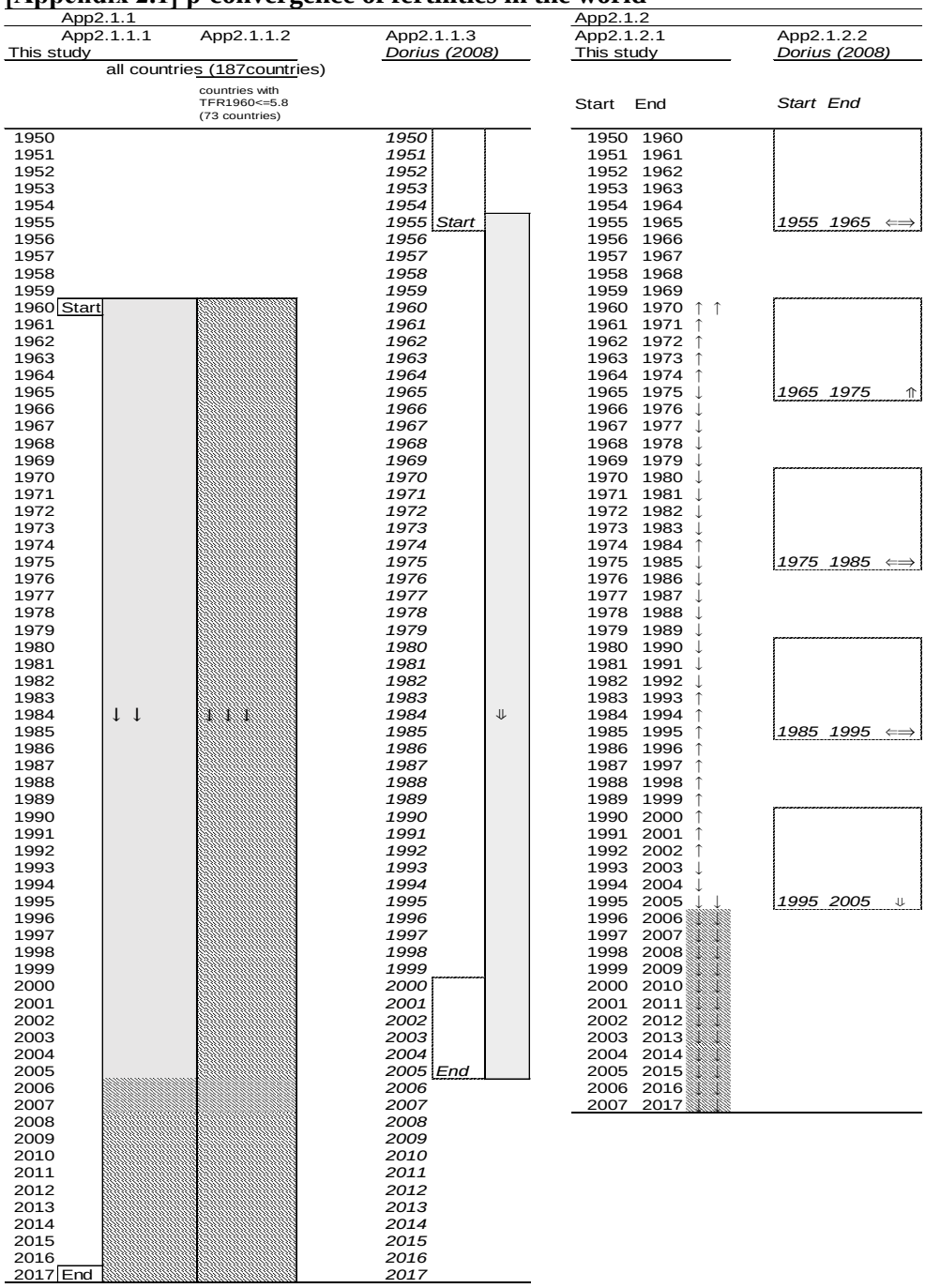
	Code	Countryname	TFR							Population	Region / Sub-region
			1960	1970	1980	1990	2000	2010	2017	(2017, thousand)	
101	SUR	Suriname	6.608	5.653	3.895	3.267	2.861	2.52	2.348	563	Americas/Latin
102	PER	Peru	6.971	6.378	5.021	3.828	2.929	2.545	2.37	32,165	Americas/Latin
103	DOM	Dominican Republic	7.555	6.182	4.422	3.465	2.892	2.597	2.392	10,767	Americas/Latin
104	HND	Honduras	7.458	7.27	6.313	5.139	4.055	2.871	2.423	9,265	Americas/Latin
105	ZAF	South Africa	6.041	5.67	4.837	3.654	2.829	2.588	2.43	56,717	Sub-Sahara
106	PRY	Paraguay	6.5	5.739	5.174	4.547	3.553	2.73	2.453	6,811	Americas/Latin
107	MAR	Morocco	7.04	6.646	5.684	4.057	2.777	2.578	2.454	35,740	MENA
108	UZB	Uzbekistan	6.255	6.326	5.112	4.072	2.58	2.342	2.455	32,387	C.Asia
109	ECU	Ecuador	6.721	6.138	4.727	3.767	3.027	2.656	2.458	16,625	Americas/Latin
110	BLZ	Belize	6.5	6.299	5.849	4.508	3.6	2.715	2.475	375	Americas/Latin
111	GUY	Guyana	6.372	5.38	3.817	3.069	3.017	2.655	2.485	778	Americas/Latin
112	PAN	Panama	5.87	5.173	3.884	3.057	2.744	2.622	2.487	4,099	Americas/Latin
113	SAU	Saudi Arabia	7.216	7.28	7.206	5.911	3.971	2.96	2.491	32,938	MENA
114	FJI	Fiji	6.461	4.543	3.907	3.398	3.09	2.669	2.493	906	EAP
115	KHM	Cambodia	6.967	6.465	5.87	5.601	3.805	2.875	2.53	16,005	EAP/E.Asia
116	OMN	Oman	7.247	7.311	8.299	7.165	3.716	2.901	2.592	4,636	MENA
117	LAO	Lao PDR	5.961	5.974	6.277	6.151	4.311	3.149	2.643	6,858	EAP/E.Asia
118	BWA	Botswana	6.615	6.645	6.214	4.54	3.387	2.884	2.683	2,292	Sub-Sahara
119	DZA	Algeria	7.524	7.643	6.794	4.726	2.514	2.889	2.709	41,318	MENA
120	MNG	Mongolia	6.953	7.569	6.209	4.052	2.143	2.637	2.713	3,076	EAP
121	KAZ	Kazakhstan	4.562	3.611	2.9	2.72	1.8	2.6	2.73	18,038	C.Asia
122	DJI	Djibouti	6.461	6.804	6.554	6.073	4.484	3.301	2.785	957	MENA
123	TKM	Turkmenistan	6.59	6.404	5.17	4.344	2.824	2.833	2.836	5,758	C.Asia
124	BOL	Bolivia	6.7	6.284	5.715	4.894	4.055	3.2	2.839	11,052	Americas/Latin
125	SYR	Syrian Arab Republic	7.467	7.572	7.094	5.31	4.043	3.21	2.865	18,270	MENA
126	HTI	Haiti	6.324	5.762	6.058	5.43	4.302	3.325	2.868	10,981	Americas/Latin
127	PHL	Philippines	7.148	6.264	5.183	4.32	3.811	3.158	2.894	104,918	EAP/E.Asia
128	GTM	Guatemala	6.896	6.642	6.342	5.437	4.598	3.375	2.92	16,914	Americas/Latin
129	KGZ	Kyrgyz Republic	5.469	5.177	4.367	3.63	2.4	3.1	3	6,198	C.Asia
130	SWZ	Eswatini	6.717	6.875	6.646	5.619	4.187	3.527	3.033	1,367	Sub-Sahara
131	LSO	Lesotho	5.839	5.808	5.589	4.919	4.089	3.303	3.044	2,233	Sub-Sahara
132	FSM	Micronesia, Fed. Sts.	6.934	6.938	6.223	4.958	4.3	3.46	3.098	106	EAP
133	ISR	Israel	3.866	3.778	3.242	2.824	2.95	3.03	3.11	8,713	MENA
134	EGY	Egypt, Arab Rep.	6.716	6.233	5.6	4.663	3.233	3.185	3.21	97,553	MENA
135	VUT	Vanuatu	7.197	6.272	5.575	4.927	4.368	3.498	3.239	276	EAP
136	JOR	Jordan	7.687	7.926	7.262	5.488	4.033	3.663	3.309	9,702	MENA
137	TJK	Tajikistan	6.547	7.003	5.688	5.226	3.907	3.507	3.313	8,921	C.Asia
138	NAM	Namibia	6.149	6.459	6.451	5.227	4.018	3.605	3.354	2,534	Sub-Sahara
139	PAK	Pakistan	6.6	6.601	6.535	6.024	4.58	3.855	3.414	197,016	S.Asia
140	TON	Tonga	7.363	5.941	5.553	4.644	4.25	3.913	3.595	108	EAP
141	KIR	Kiribati	6.788	5.457	5.07	4.688	4.058	3.843	3.609	116	EAP
142	PNG	Papua New Guinea	6.275	6.163	5.694	4.802	4.525	3.985	3.61	8,251	EAP
143	ZWE	Zimbabwe	7.158	7.417	7.095	5.176	4.055	4.028	3.682	16,530	Sub-Sahara
144	GAB	Gabon	4.384	5.081	5.684	5.421	4.539	4.083	3.72	2,025	Sub-Sahara
145	KEN	Kenya	7.946	8.081	7.455	6.066	5.178	4.373	3.793	49,700	Sub-Sahara
146	SLB	Solomon Islands	6.388	6.914	6.748	5.851	4.72	4.235	3.795	611	EAP
147	RWA	Rwanda	8.187	8.231	8.461	7.184	5.64	4.515	3.809	12,208	Sub-Sahara
148	YEM	Yemen, Rep.	7.488	7.813	8.754	8.606	6.313	4.674	3.889	28,250	MENA
149	WSM	Samoa	7.651	7.194	6.203	5.118	4.503	4.338	3.926	196	EAP
150	GHA	Ghana	6.749	6.95	6.539	5.602	4.826	4.273	3.926	28,834	Sub-Sahara

[Appendix 1] continued 3

	Code	Countryname	TFR							Population	Region / Sub-region
			1960	1970	1980	1990	2000	2010	2017	(2017, thousand)	
151	ETH	Ethiopia	6.88	6.978	7.316	7.246	6.529	4.924	4.081	104,957	Sub-Sahara
152	MDG	Madagascar	7.3	7.27	6.725	6.179	5.551	4.603	4.129	25,571	Sub-Sahara
153	COM	Comoros	6.792	7.061	7.078	6.412	5.384	4.754	4.275	814	Sub-Sahara
154	IRQ	Iraq	6.252	7.362	6.569	5.882	4.894	4.562	4.309	38,275	MENA
155	SLE	Sierra Leone	6.127	6.496	6.69	6.721	6.319	5.202	4.359	7,557	Sub-Sahara
156	TGO	Togo	6.521	7.084	7.207	6.324	5.41	4.868	4.384	7,798	Sub-Sahara
157	STP	Sao Tome and Principe	6.242	6.468	6.386	5.82	5.278	4.788	4.394	204	Sub-Sahara
158	SDN	Sudan	6.691	6.888	6.802	6.152	5.471	4.876	4.469	40,533	Sub-Sahara
159	AFG	Afghanistan	7.45	7.45	7.449	7.466	7.494	5.816	4.477	35,530	S.Asia
160	MWI	Malawi	6.94	7.303	7.643	6.922	6.149	5.308	4.505	18,622	Sub-Sahara
161	LBR	Liberia	6.406	6.695	6.973	6.499	5.88	5.023	4.513	4,732	Sub-Sahara
162	GNB	Guinea-Bissau	5.921	6.041	6.487	6.627	5.82	5.049	4.556	1,861	Sub-Sahara
163	COG	Congo, Rep.	5.88	6.288	6.21	5.349	5.096	4.948	4.599	5,261	Sub-Sahara
164	GNQ	Equatorial Guinea	5.653	5.808	5.835	5.987	5.834	5.209	4.599	1,268	Sub-Sahara
165	MRT	Mauritania	6.775	6.784	6.457	6.04	5.453	4.983	4.612	4,420	Sub-Sahara
166	CMR	Cameroon	5.647	6.203	6.625	6.436	5.58	5.111	4.639	24,054	Sub-Sahara
167	SEN	Senegal	6.996	7.289	7.312	6.53	5.471	5.063	4.695	15,851	Sub-Sahara
168	SSD	South Sudan	6.721	6.881	6.85	6.761	6.223	5.376	4.774	12,576	Sub-Sahara
169	GIN	Guinea	6.114	6.225	6.529	6.598	6.082	5.336	4.777	12,717	Sub-Sahara
170	CAF	Central African Republic	5.84	5.954	5.954	5.808	5.5	5.215	4.796	4,659	Sub-Sahara
171	CIV	Cote d'Ivoire	7.691	7.936	7.59	6.622	5.859	5.269	4.846	24,295	Sub-Sahara
172	BEN	Benin	6.282	6.748	7.025	6.744	5.962	5.362	4.906	11,176	Sub-Sahara
173	ZMB	Zambia	7.115	7.367	7.087	6.442	6.036	5.397	4.925	17,094	Sub-Sahara
174	TZA	Tanzania	6.806	6.771	6.653	6.213	5.689	5.427	4.953	57,310	Sub-Sahara
175	MOZ	Mozambique	6.954	6.84	6.464	6.211	5.818	5.562	5.179	29,669	Sub-Sahara
176	BFA	Burkina Faso	6.291	6.623	7.127	7.007	6.592	5.868	5.271	19,193	Sub-Sahara
177	GMB	Gambia, The	5.573	6.093	6.337	6.107	5.947	5.707	5.358	2,101	Sub-Sahara
178	TLS	Timor-Leste	6.373	5.917	4.767	5.34	7.112	6.234	5.391	1,296	EAP
179	NGA	Nigeria	6.354	6.471	6.783	6.49	6.106	5.839	5.457	190,886	Sub-Sahara
180	UGA	Uganda	6.999	7.115	7.1	7.091	6.865	6.154	5.5	42,863	Sub-Sahara
181	BDI	Burundi	6.953	7.289	7.418	7.505	7.008	6.256	5.615	10,864	Sub-Sahara
182	AGO	Angola	7.478	7.601	7.504	7.247	6.639	6.162	5.623	29,784	Sub-Sahara
183	TCD	Chad	6.25	6.528	6.958	7.313	7.354	6.592	5.846	14,900	Sub-Sahara
184	MLI	Mali	6.967	7.133	7.15	7.165	6.897	6.547	5.968	18,542	Sub-Sahara
185	COD	Congo, Dem. Rep.	6.001	6.215	6.535	6.746	6.751	6.544	6.018	81,340	Sub-Sahara
186	SOM	Somalia	7.25	7.182	7.013	7.397	7.623	6.866	6.171	14,743	Sub-Sahara
187	NER	Niger	7.454	7.567	7.844	7.772	7.679	7.487	7.184	21,477	Sub-Sahara

[Appendix 2] Comparison of the results with Dorius (2008)

[Appendix 2.1] β-convergence of fertilities in the world



Notes: Appendix 2.1 compares the estimation periods as the length of the bars and their statistical significances. App2.1.1.1 stands for the estimation of this study with all samples for 1960–2017 (Figure 2.1; App4.1); App2.1.1.2 stands for the estimation of this study with TFR1960≦5.8 (Figure 2.2; App4.1.2); App2.1.1.3 stands for estimations by Dorius (2008). Dorius (2008) employed the quinquennial data and named each category based on their final years. "↓(↑)," "↓↓(↑↑)," and "↓↓↓(↑↑↑)" stands for the results of this study with negative (positive) convergence coefficient with adjusted R^2<0.1, 0.1≦adjusted R^2<0.3, and adjusted R^2≧0.3, respectively. ⇓,⇑ and ⇐⇒ stand for statistically significant convergence, statistically significant divergence, and non-statistically significant, respectively, by Dorius (2008). App2.1.2 compares ten-year-period β-convergence estimations. App2.1.2.1 shows the results of this study (Figure 3 and Appendix 5); App2.1.2.2 stands for estimations by Dorius (2008). Diagonal lined (Darker shadowed) parts are a new finding of this study.

[Appendix 2.2] Comparison of the inequality indices of TFRs in the world

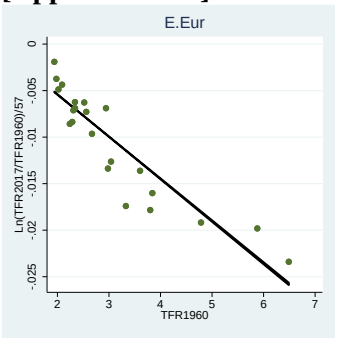
Gini	App2.2.1				MLD	App2.2.2				Theil	App2.2.3			
	App2.2.1.1		App2.2.1.2			App2.2.2.1		App2.2.2.2			App2.2.3.1		App2.2.3.2	
Year	This study		*Dorius (2008)*		Year	This study		*Dorius (2008)*		Year	This study		*Dorius (2008)*	
1950					1950					1950				
1951					1951					1951				
1952					1952					1952				
1953					1953					1953				
1954					1954					1954				
1955			***0.172***		1955			***0.066***		1955			***0.057***	
1956					1956					1956				
1957					1957					1957				
1958					1958					1958				
1959					1959					1959				
1960	**0.171**			⇑	1960	**0.067**			⇑	1960	**0.058**			⇑
1961	0.170				1961	0.069				1961	0.059			
1962	0.174				1962	0.072				1962	0.061			
1963	0.176	⇑			1963	0.074	⇑			1963	0.062	⇑		
1964	0.178				1964	0.075				1964	0.064			
1965	**0.182**		***0.175***		1965	**0.079**		***0.069***		1965	**0.066**		***0.059***	
1966	0.188				1966	0.087				1966	0.072			
1967	0.185				1967	0.082				1967	0.069			
1968	0.186				1968	0.082				1968	0.069			
1969	0.186				1969	0.082				1969	0.069			
1970	0.185	⇑		⇑	1970	0.081	⇑		⇑	1970	0.068	⇑		⇑
1971	0.189				1971	0.081				1971	0.069			
1972	0.199				1972	0.085				1972	0.073			
1973	0.208				1973	0.088				1973	0.076			
1974	0.216				1974	0.089				1974	0.078			
1975	**0.226**		***0.197***		1975	**0.094**		***0.084***		1975	**0.084**		***0.072***	
1976	0.235				1976	0.098				1976	0.089			
1977	0.242				1977	0.101				1977	0.093			
1978	0.249				1978	0.105				1978	0.098			
1979	0.253				1979	0.107				1979	0.101			
1980	0.255	⇑		⇑	1980	0.108	⇑		⇑	1980	0.103	⇑		⇑
1981	0.257				1981	0.110				1981	0.105			
1982	0.255				1982	0.107				1982	0.103			
1983	0.254				1983	0.106				1983	0.102			
1984	0.252				1984	0.104				1984	0.100			
1985	**0.249**		***0.254***		1985	**0.101**		***0.105***		1985	**0.098**		***0.102***	
1986	0.247				1986	0.098				1986	0.096			
1987	0.245				1987	0.096				1987	0.094			
1988	0.244				1988	0.095				1988	0.093			
1989	0.245				1989	0.096				1989	0.095			
1990	0.248			⇑	1990	0.097			⇑	1990	0.097			⇑
1991	0.253	⇑			1991	0.102	⇑			1991	0.103	⇑		
1992	0.260				1992	0.108				1992	0.109			
1993	0.269				1993	0.115				1993	0.116			
1994	0.274				1994	0.120				1994	0.121			
1995	**0.280**		***0.267***		1995	**0.126**		***1.114***		1995	**0.127**		***1.114***	
1996	0.284				1996	0.129				1996	0.130			
1997	0.286				1997	0.130				1997	0.132			
1998	0.286				1998	0.130				1998	0.132			
1999	0.286				1999	0.130				1999	0.132			
2000	0.281				2000	0.125				2000	0.129			
2001	0.280	⇓		⇓	2001	0.124	⇓		⇓	2001	0.128	⇓		⇓
2002	0.277				2002	0.121				2002	0.125			
2003	0.272				2003	0.117				2003	0.122			
2004	0.268				2004	0.113				2004	0.119			
2005	**0.266**		***0.258***		2005	**0.111**		***0.105***		2005	**0.118**		***0.110***	
2006	0.261				2006	0.107				2006	0.114			
2007	0.255				2007	0.103				2007	0.111			
2008	0.250				2008	0.099				2008	0.108			
2009	0.248				2009	0.098				2009	0.107			
2010	0.246				2010	0.096				2010	0.105			
2011	0.244				2011	0.095				2011	0.105			
2012	0.241				2012	0.093				2012	0.102			
2013	0.240	⇓			2013	0.092	⇓			2013	0.102	⇓		
2014	0.236				2014	0.090				2014	0.099			
2015	0.233				2015	0.088				2015	0.097			
2016	0.231				2016	0.086				2016	0.095			
2017	**0.229**				2017	**0.085**				2017	**0.094**			

Notes: Appendix 2.2 compares the estimation results of inequality indices. ⇓ and ⇑ are inserted by the author of this study to demonstrate comparison of the indices between the start and the end of the period. Diagonal lined (Darker shadowed) parts are a new finding of this study.

[Appendix 3] Results of estimations for sub-regions

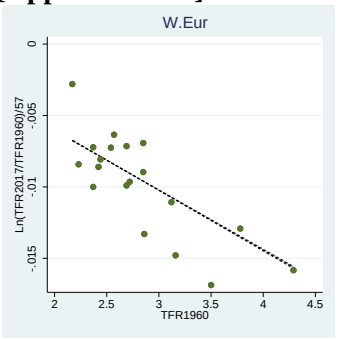
[Appendix 3.1] β-convergence of fertilities for 1960–2017 (population weight is applied)

[Appendix 3.1.1] Eastern Europe



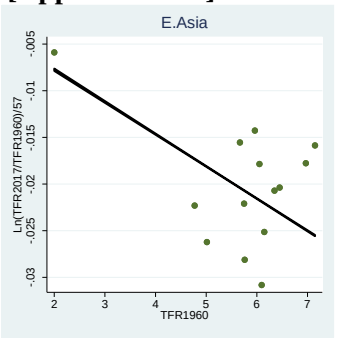
Adj R^2: 0.700

[Appendix 3.1.2] Western Europe



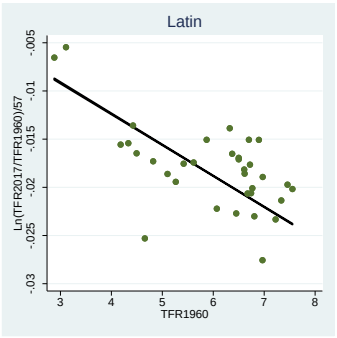
Adj R^2: 0.229

[Appendix 3.1.3] East Asia



Adj R^2: 0.552

[Appendix 3.1.4] Latin America and the Caribbean

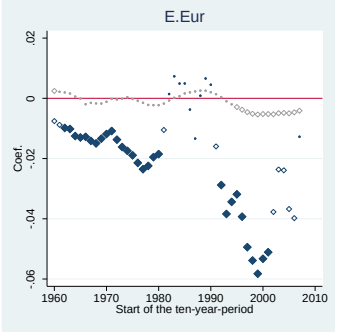


Adj R^2: 0.555

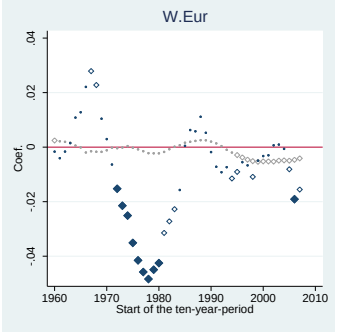
Notes: Appendices 3.1.1–4 stand for estimation results on β-convergence for 1960–2017 by equation (1). Estimated coefficients, S.E., and adjusted R^2 are shown in Appendix 4. Solid lines stand for adjusted $R^2 \geqq 3$; dashed lines stand for $3 >$ adjusted $R^2 \geqq 1$. Width of the lines stands for 95% confidence intervals.

[Appendix 3.2] β-convergence estimations from 1960–1970 to 2007–2017 (population weight is applied)

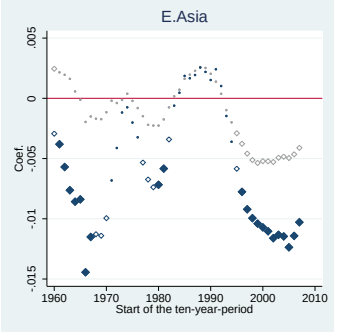
[Appendix 3.2.1] Eastern Europe



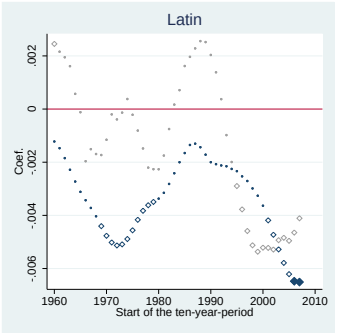
[Appendix 3.2.2] Western Europe



[Appendix 2.2.3] East Asia



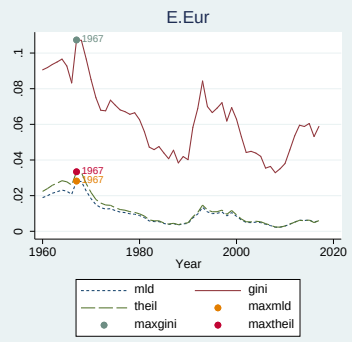
[Appendix 3.2.4] Latin America and the Caribbean



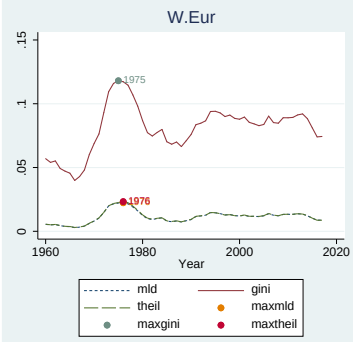
Notes: Appendices 3.2.1–4 stand for estimation results on ten-year-period piecewise β-convergence estimations on sub-regions from 1960–1970 to 2007–2017 by equation (1). Gray dots, which stand for the estimation results with all samples shown in Figure 3, are for the reference. "Coef." stands for estimated convergence coefficient. "Start of the ten-year-period" stands for the year of the first year in ten years: For instance, "2007" stands for 2007–2017. The patterns of the dots stand for the adjusted R^2. Tiny dots stand for adjusted $R^2 < 0.1$; hollow diamonds stand for $0.1 \leqq$ adjusted $R^2 < 0.3$; bigger diamonds stand for adjusted $R^2 \geqq 0.3$. Estimated coefficients, $P>|t|$, and adjusted R^2 are shown in Appendix 5.

[Appendix 3.3] Gini coefficient, the MLD, and the Theil index of TFRs (population weight is applied)

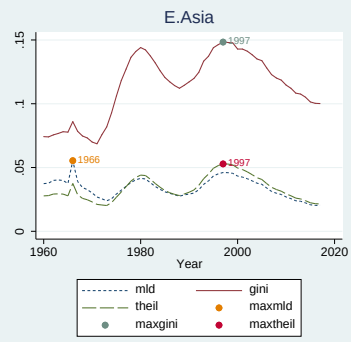
[Appendix 3.3.1] Eastern Europe



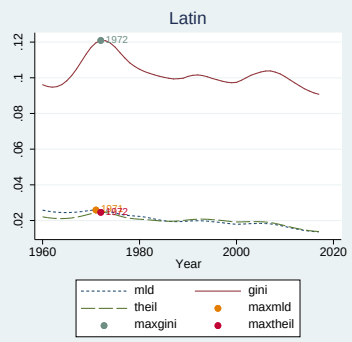
[Appendix 3.3.2] Western Europe



[Appendix 2.3.3] East Asia



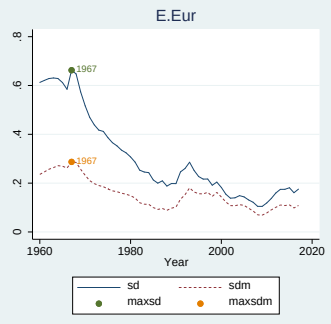
[Appendix 3.3.4] Latin America and the Caribbean



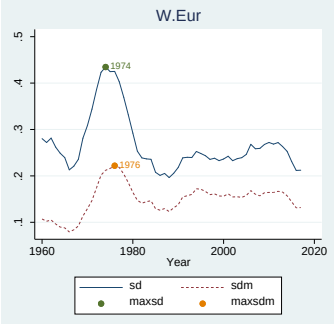
Notes: "mld," "gini," and "theil" stand for the mean log deviation, Gini coefficient, and Theil index, respectively.

[Appendix 3.4] Standard deviation and its ratio to the mean (population weight is applied)

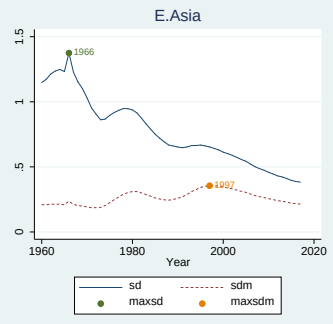
[Appendix 3.4.1] Eastern Europe



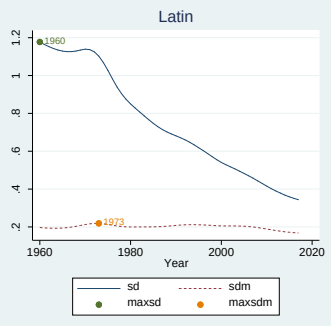
[Appendix 3.4.2] Western Europe



[Appendix 3.4.3] East Asia



[Appendix 3.4.4] Latin America and the Caribbean



Notes: "sd" stands for standard deviation; "sdm" stands for the ratio of standard deviation to the mean of TFR.

[Appendix 4] Estimation results on β-convergence for 1960–2017 (population weight is applied)

Explained variable:Ln (TFR2017/TR1960)/57						
Est. Number	**App 4.1**			**App 4.1.2**		
	World					
				World (Est. on TFR1960<=5.8)		
	Coef.	Robust S.E.		Coef.	Robust S.E.	
TFR1960	-0.00188	0.00001	***	-0.00408	0.00001	***
Constant	-0.00523	0.00006	***	-0.00523	0.00003	***
Adj. R^2	0.201			0.848		
N of countries	187			73		

Explained variable:Ln (TFR2017/TR1960)/57									
Est. number	**App 4.2**			**App. 4.2.1**			**App. 4.2.2**		
	Europe								
				E.Eur			**W.Eur**		
	Coef.	Robust S.E.		Coef.	Robust S.E.		Coef.	Robust S.E.	
TFR1960	-0.00447	0.00001	***	-0.00453	0.00002	***	-0.00420	0.00002	***
Constant	0.00327	0.00003	***	0.00365	0.00004	***	0.00236	0.00006	***
Adj. R^2	0.532			0.700			0.229		
N of countries	41			19			22		

Explained variable:Ln (TFR2017/TR1960)/57						
Est. number	**App 4.3**			**App 4.3.1**		
	E.Asia_Pac					
				E.Asia		
	Coef.	Robust S.E.		Coef.	Robust S.E.	
TFR1960	-0.00343	0.00002	***	-0.00345	0.00002	***
Constant	-0.00086	0.00010	***	-0.00084	0.00010	***
Adj. R^2	0.544			0.552		
N of countries	31			14		

Explained variable:Ln (TFR2017/TR1960)/57									
Est. number	**App 4.4**			**App 4.5**			**App 4.5.1**		
	C.Asia			**Americas**					
							Latin		
	Coef.	Robust S.E.		Coef.	Robust S.E.		Coef.	Robust S.E.	
TFR1960	-0.00338	0.00001	***	-0.00272	0.00001	***	-0.00322	0.00001	***
Constant	0.00636	0.00007	***	-0.00276	0.00004	***	0.00050	0.00007	***
Adj. R^2	0.729			0.705			0.555		
N of countries	5			36			34		

Explained variable:Ln (TFR2017/TR1960)/57									
Est. number	**App 4.6**			**App 4.7**			**App 4.8**		
	MENA			**Subsahara**			**S.Asia**		
	Coef.	Robust S.E.		Coef.	Robust S.E.		Coef.	Robust S.E.	
TFR1960	-0.00267	0.00002	***	-0.00243	0.00002	***	0.00167	0.00003	***
Constant	0.00070	0.00017	***	0.01002	0.00014	***	-0.02648	0.00020	***
Adj. R^2	0.083			0.097			0.071		
N of countries	20			46			8		

Note: ***, **, * denote statistical significance at the 1, 5 and 10 % levels, respectively.

[Appendix 5] Results on ten-year-period piecewise β-convergence estimations

Year		World			E.Asia_Pac			E.Asia			S.Asia		
Start	End	Coef.	P>|t|	Adj. R^2	Coef.	P>|t|	Adj. R^2	Coef.	P>|t|	Adj. R^2	Coef.	P>|t|	Adj. R^2
1960	1970	0.00245	0.000	0.105	-0.00247	0.000	0.155	-0.00293	0.000	0.228	0.00902	0.000	0.621
1961	1971	0.00216	0.000	0.073	-0.00348	0.000	0.348	-0.00381	0.000	0.415	0.00990	0.000	0.709
1962	1972	0.00195	0.000	0.046	-0.00533	0.000	0.435	-0.00570	0.000	0.487	0.01062	0.000	0.782
1963	1973	0.00161	0.000	0.024	-0.00715	0.000	0.457	-0.00763	0.000	0.503	0.01112	0.000	0.833
1964	1974	0.00057	0.000	0.002	-0.00817	0.000	0.413	-0.00858	0.000	0.432	0.01138	0.000	0.863
1965	1975	-0.00012	0.000	0.000	-0.00799	0.000	0.304	-0.00839	0.000	0.315	0.01136	0.000	0.875
1966	1976	-0.00196	0.000	0.020	-0.01370	0.000	0.536	-0.01444	0.000	0.561	0.01103	0.000	0.872
1967	1977	-0.00151	0.000	0.011	-0.01099	0.000	0.324	-0.01151	0.000	0.333	0.01042	0.000	0.858
1968	1978	-0.00169	0.000	0.012	-0.01077	0.000	0.253	-0.01128	0.000	0.261	0.00958	0.000	0.831
1969	1979	-0.00173	0.000	0.011	-0.01090	0.000	0.222	-0.01141	0.000	0.229	0.00857	0.000	0.788
1970	1980	-0.00115	0.000	0.005	-0.00954	0.000	0.159	-0.00995	0.000	0.162	0.00744	0.000	0.724
1971	1981	-0.00020	0.000	0.000	-0.00659	0.000	0.078	-0.00682	0.000	0.080	0.00628	0.000	0.629
1972	1982	-0.00039	0.000	0.001	-0.00411	0.000	0.037	-0.00412	0.000	0.035	0.00516	0.000	0.503
1973	1983	-0.00013	0.000	0.000	-0.00153	0.000	0.007	-0.00118	0.000	0.004	0.00413	0.000	0.357
1974	1984	0.00038	0.000	0.001	-0.00090	0.000	0.003	-0.00075	0.000	0.002	0.00323	0.000	0.222
1975	1985	-0.00021	0.000	0.001	-0.00225	0.000	0.031	-0.00201	0.000	0.024	0.00247	0.000	0.122
1976	1986	-0.00081	0.000	0.009	-0.00329	0.000	0.085	-0.00324	0.000	0.080	0.00187	0.000	0.063
1977	1987	-0.00148	0.000	0.032	-0.00523	0.000	0.176	-0.00533	0.000	0.175	0.00139	0.000	0.031
1978	1988	-0.00220	0.000	0.076	-0.00659	0.000	0.284	-0.00674	0.000	0.286	0.00101	0.000	0.014
1979	1989	-0.00226	0.000	0.081	-0.00723	0.000	0.285	-0.00738	0.000	0.286	0.00074	0.000	0.007
1980	1990	-0.00226	0.000	0.084	-0.00712	0.000	0.305	-0.00717	0.000	0.303	0.00057	0.000	0.004
1981	1991	-0.00175	0.000	0.057	-0.00581	0.000	0.336	-0.00583	0.000	0.341	0.00048	0.000	0.003
1982	1992	-0.00075	0.000	0.010	-0.00357	0.000	0.213	-0.00341	0.000	0.228	0.00041	0.000	0.002
1983	1993	0.00017	0.000	0.000	-0.00095	0.000	0.015	-0.00061	0.000	0.009	0.00034	0.000	0.001
1984	1994	0.00071	0.000	0.006	-0.00007	0.326	0.000	0.00046	0.000	0.002	0.00022	0.000	0.001
1985	1995	0.00162	0.000	0.024	0.00128	0.000	0.006	0.00186	0.000	0.013	0.00002	0.606	0.000
1986	1996	0.00196	0.000	0.027	0.00101	0.000	0.002	0.00167	0.000	0.007	-0.00028	0.000	0.001
1987	1997	0.00228	0.000	0.033	0.00123	0.000	0.003	0.00193	0.000	0.007	-0.00067	0.000	0.007
1988	1998	0.00256	0.000	0.042	0.00190	0.000	0.006	0.00257	0.000	0.012	-0.00110	0.000	0.020
1989	1999	0.00252	0.000	0.045	0.00174	0.000	0.006	0.00219	0.000	0.010	-0.00155	0.000	0.041
1990	2000	0.00204	0.000	0.036	0.00141	0.000	0.004	0.00152	0.000	0.005	-0.00191	0.000	0.063
1991	2001	0.00138	0.000	0.021	0.00234	0.000	0.021	0.00241	0.000	0.023	-0.00218	0.000	0.082
1992	2002	0.00037	0.000	0.002	0.00117	0.000	0.007	0.00102	0.000	0.006	-0.00229	0.000	0.091
1993	2003	-0.00098	0.000	0.016	-0.00120	0.000	0.011	-0.00147	0.000	0.016	-0.00224	0.000	0.088
1994	2004	-0.00199	0.000	0.066	-0.00325	0.000	0.074	-0.00361	0.000	0.088	-0.00205	0.000	0.078
1995	2005	-0.00290	0.000	0.131	-0.00542	0.000	0.158	-0.00585	0.000	0.174	-0.00174	0.000	0.059
1996	2006	-0.00377	0.000	0.200	-0.00727	0.000	0.284	-0.00776	0.000	0.304	-0.00128	0.000	0.035
1997	2007	-0.00459	0.000	0.261	-0.00868	0.000	0.449	-0.00921	0.000	0.477	-0.00075	0.000	0.013
1998	2008	-0.00512	0.000	0.286	-0.00939	0.000	0.507	-0.00995	0.000	0.536	-0.00019	0.000	0.001
1999	2009	-0.00537	0.000	0.290	-0.00982	0.000	0.537	-0.01040	0.000	0.564	0.00037	0.000	0.003
2000	2010	-0.00521	0.000	0.279	-0.01010	0.000	0.572	-0.01071	0.000	0.599	0.00081	0.000	0.013
2001	2011	-0.00522	0.000	0.283	-0.01041	0.000	0.697	-0.01103	0.000	0.737	0.00108	0.000	0.021
2002	2012	-0.00529	0.000	0.280	-0.01093	0.000	0.762	-0.01161	0.000	0.810	0.00113	0.000	0.021
2003	2013	-0.00493	0.000	0.264	-0.01065	0.000	0.749	-0.01133	0.000	0.792	0.00094	0.000	0.014
2004	2014	-0.00484	0.000	0.263	-0.01076	0.000	0.767	-0.01146	0.000	0.810	0.00054	0.000	0.005
2005	2015	-0.00496	0.000	0.267	-0.01158	0.000	0.770	-0.01237	0.000	0.811	-0.00006	0.141	0.000
2006	2016	-0.00465	0.000	0.261	-0.01074	0.000	0.773	-0.01142	0.000	0.822	-0.00084	0.000	0.016
2007	2017	-0.00411	0.000	0.246	-0.00976	0.000	0.558	-0.01028	0.000	0.584	-0.00173	0.000	0.084

[Appendix 5] continued 1

Year	C.Asia			MENA			Subsahara			Eur		
	Coef.	P>|t|	Adj. R^2	Coef.	P>|t|	Adj. R^2	Coef.	P>|t|	Adj. R^2	Coef.	P>|t|	Adj. R^2
1960	0.01375	0.000	0.951	0.00408	0.000	0.093	-0.00010	0.000	0.000	-0.00642	0.000	0.075
1961	0.01107	0.000	0.945	0.00440	0.000	0.127	-0.00020	0.000	0.001	-0.00800	0.000	0.111
1962	0.00847	0.000	0.937	0.00502	0.000	0.186	-0.00030	0.000	0.001	-0.01030	0.000	0.136
1963	0.00611	0.000	0.924	0.00589	0.000	0.288	-0.00036	0.000	0.002	-0.01352	0.000	0.152
1964	0.00403	0.000	0.902	0.00639	0.000	0.387	-0.00036	0.000	0.002	-0.01901	0.000	0.224
1965	0.00225	0.000	0.848	0.00610	0.000	0.413	-0.00031	0.000	0.001	-0.02073	0.000	0.229
1966	0.00082	0.000	0.598	0.00627	0.000	0.444	-0.00018	0.000	0.000	-0.02230	0.000	0.235
1967	-0.00031	0.000	0.283	0.00633	0.000	0.432	0.00003	0.215	0.000	-0.01794	0.000	0.196
1968	-0.00117	0.000	0.901	0.00620	0.000	0.375	0.00033	0.000	0.001	-0.01774	0.000	0.202
1969	-0.00025	0.000	0.094	0.00586	0.000	0.295	0.00071	0.000	0.005	-0.01572	0.000	0.170
1970	0.00023	0.000	0.054	0.00560	0.000	0.237	0.00117	0.000	0.012	-0.01234	0.000	0.144
1971	-0.00096	0.000	0.538	0.00532	0.000	0.193	0.00166	0.000	0.023	-0.01259	0.000	0.150
1972	-0.00200	0.000	0.712	0.00497	0.000	0.157	0.00218	0.000	0.039	-0.01436	0.000	0.175
1973	-0.00289	0.000	0.705	0.00439	0.000	0.121	0.00267	0.000	0.057	-0.01578	0.000	0.174
1974	-0.00380	0.000	0.692	0.00414	0.000	0.111	0.00322	0.000	0.079	-0.01629	0.000	0.184
1975	-0.00425	0.000	0.649	0.00429	0.000	0.130	0.00375	0.000	0.102	-0.02092	0.000	0.272
1976	-0.00547	0.000	0.686	0.00425	0.000	0.145	0.00416	0.000	0.121	-0.02411	0.000	0.284
1977	-0.00636	0.000	0.734	0.00415	0.000	0.163	0.00448	0.000	0.137	-0.02487	0.000	0.264
1978	-0.00702	0.000	0.669	0.00400	0.000	0.179	0.00478	0.000	0.151	-0.02522	0.000	0.291
1979	-0.00488	0.000	0.529	0.00369	0.000	0.176	0.00508	0.000	0.164	-0.02116	0.000	0.234
1980	-0.00499	0.000	0.534	0.00313	0.000	0.137	0.00538	0.000	0.177	-0.02101	0.000	0.240
1981	-0.00127	0.000	0.200	0.00233	0.000	0.074	0.00580	0.000	0.199	-0.01488	0.000	0.138
1982	0.00057	0.000	0.064	0.00138	0.000	0.023	0.00613	0.000	0.221	-0.01866	0.000	0.206
1983	0.00415	0.000	0.828	0.00021	0.000	0.000	0.00661	0.000	0.261	-0.02687	0.000	0.322
1984	0.00357	0.000	0.439	-0.00094	0.000	0.007	0.00676	0.000	0.288	-0.02736	0.000	0.350
1985	0.00432	0.000	0.891	-0.00191	0.000	0.022	0.00690	0.000	0.327	-0.03156	0.000	0.372
1986	0.00645	0.000	0.882	-0.00271	0.000	0.037	0.00690	0.000	0.371	-0.04140	0.000	0.482
1987	0.00873	0.000	0.900	-0.00322	0.000	0.045	0.00682	0.000	0.427	-0.04868	0.000	0.553
1988	0.01235	0.000	0.969	-0.00345	0.000	0.045	0.00655	0.000	0.479	-0.04717	0.000	0.494
1989	0.00774	0.000	0.866	-0.00330	0.000	0.038	0.00603	0.000	0.505	-0.04983	0.000	0.451
1990	0.00208	0.000	0.112	-0.00288	0.000	0.028	0.00544	0.000	0.518	-0.04428	0.000	0.357
1991	-0.00565	0.000	0.212	-0.00220	0.000	0.017	0.00472	0.000	0.487	-0.03972	0.000	0.341
1992	-0.00838	0.000	0.430	-0.00144	0.000	0.008	0.00393	0.000	0.408	-0.03380	0.000	0.303
1993	-0.01318	0.000	0.524	-0.00064	0.000	0.002	0.00310	0.000	0.289	-0.03038	0.000	0.288
1994	-0.01545	0.000	0.638	0.00004	0.000	0.000	0.00235	0.000	0.171	-0.02740	0.000	0.254
1995	-0.01758	0.000	0.590	0.00033	0.000	0.001	0.00164	0.000	0.080	-0.01877	0.000	0.148
1996	-0.02079	0.000	0.639	0.00026	0.000	0.001	0.00108	0.000	0.032	-0.01521	0.000	0.115
1997	-0.02281	0.000	0.746	-0.00014	0.000	0.000	0.00056	0.000	0.008	-0.02132	0.000	0.238
1998	-0.02782	0.000	0.786	-0.00086	0.000	0.006	0.00016	0.000	0.001	-0.02483	0.000	0.306
1999	-0.02686	0.000	0.748	-0.00177	0.000	0.025	-0.00008	0.000	0.000	-0.03021	0.000	0.382
2000	-0.02514	0.000	0.547	-0.00266	0.000	0.048	-0.00028	0.000	0.002	-0.02513	0.000	0.313
2001	-0.02006	0.000	0.361	-0.00340	0.000	0.070	-0.00038	0.000	0.003	-0.02220	0.000	0.264
2002	-0.01955	0.000	0.257	-0.00388	0.000	0.083	-0.00036	0.000	0.003	-0.02075	0.000	0.193
2003	-0.01487	0.000	0.311	-0.00407	0.000	0.089	-0.00028	0.000	0.002	-0.01969	0.000	0.180
2004	-0.01344	0.000	0.260	-0.00407	0.000	0.091	-0.00015	0.000	0.000	-0.02148	0.000	0.221
2005	-0.01331	0.000	0.347	-0.00387	0.000	0.088	0.00001	0.000	0.000	-0.03006	0.000	0.323
2006	-0.00892	0.000	0.253	-0.00349	0.000	0.081	0.00014	0.000	0.000	-0.03416	0.000	0.430
2007	-0.00699	0.000	0.113	-0.00307	0.000	0.076	0.00030	0.000	0.002	-0.02407	0.000	0.288

[Appendix 5] continued 2

Year		C.Asia			MENA			Subsahara			Eur		
Start	End	Coef.	P>|t|	Adj. R^2	Coef.	P>|t|	Adj. R^2	Coef.	P>|t|	Adj. R^2	Coef.	P>|t|	Adj. R^2
1960	1970	0.01375	0.000	0.951	0.00408	0.000	0.093	-0.00010	0.000	0.000	-0.00642	0.000	0.075
1961	1971	0.01107	0.000	0.945	0.00440	0.000	0.127	-0.00020	0.000	0.001	-0.00800	0.000	0.111
1962	1972	0.00847	0.000	0.937	0.00502	0.000	0.186	-0.00030	0.000	0.001	-0.01030	0.000	0.136
1963	1973	0.00611	0.000	0.924	0.00589	0.000	0.288	-0.00036	0.000	0.002	-0.01352	0.000	0.152
1964	1974	0.00403	0.000	0.902	0.00639	0.000	0.387	-0.00036	0.000	0.002	-0.01901	0.000	0.224
1965	1975	0.00225	0.000	0.848	0.00610	0.000	0.413	-0.00031	0.000	0.001	-0.02073	0.000	0.229
1966	1976	0.00082	0.000	0.598	0.00627	0.000	0.444	-0.00018	0.000	0.000	-0.02230	0.000	0.235
1967	1977	-0.00031	0.000	0.283	0.00633	0.000	0.432	0.00003	0.215	0.000	-0.01794	0.000	0.196
1968	1978	-0.00117	0.000	0.901	0.00620	0.000	0.375	0.00033	0.000	0.001	-0.01774	0.000	0.202
1969	1979	-0.00025	0.000	0.094	0.00586	0.000	0.295	0.00071	0.000	0.005	-0.01572	0.000	0.170
1970	1980	0.00023	0.000	0.054	0.00560	0.000	0.237	0.00117	0.000	0.012	-0.01234	0.000	0.144
1971	1981	-0.00096	0.000	0.538	0.00532	0.000	0.193	0.00166	0.000	0.023	-0.01259	0.000	0.150
1972	1982	-0.00200	0.000	0.712	0.00497	0.000	0.157	0.00218	0.000	0.039	-0.01436	0.000	0.175
1973	1983	-0.00289	0.000	0.705	0.00439	0.000	0.121	0.00267	0.000	0.057	-0.01578	0.000	0.174
1974	1984	-0.00380	0.000	0.692	0.00414	0.000	0.111	0.00322	0.000	0.079	-0.01629	0.000	0.184
1975	1985	-0.00425	0.000	0.649	0.00429	0.000	0.130	0.00375	0.000	0.102	-0.02092	0.000	0.272
1976	1986	-0.00547	0.000	0.686	0.00425	0.000	0.145	0.00416	0.000	0.121	-0.02411	0.000	0.284
1977	1987	-0.00636	0.000	0.734	0.00415	0.000	0.163	0.00448	0.000	0.137	-0.02487	0.000	0.264
1978	1988	-0.00702	0.000	0.669	0.00400	0.000	0.179	0.00478	0.000	0.151	-0.02522	0.000	0.291
1979	1989	-0.00488	0.000	0.529	0.00369	0.000	0.176	0.00508	0.000	0.164	-0.02116	0.000	0.234
1980	1990	-0.00499	0.000	0.534	0.00313	0.000	0.137	0.00538	0.000	0.177	-0.02101	0.000	0.240
1981	1991	-0.00127	0.000	0.200	0.00233	0.000	0.074	0.00580	0.000	0.199	-0.01488	0.000	0.138
1982	1992	0.00057	0.000	0.064	0.00138	0.000	0.023	0.00613	0.000	0.221	-0.01866	0.000	0.206
1983	1993	0.00415	0.000	0.828	0.00021	0.000	0.000	0.00661	0.000	0.261	-0.02687	0.000	0.322
1984	1994	0.00357	0.000	0.439	-0.00094	0.000	0.007	0.00676	0.000	0.288	-0.02736	0.000	0.350
1985	1995	0.00432	0.000	0.891	-0.00191	0.000	0.022	0.00690	0.000	0.327	-0.03156	0.000	0.372
1986	1996	0.00645	0.000	0.882	-0.00271	0.000	0.037	0.00690	0.000	0.371	-0.04140	0.000	0.482
1987	1997	0.00873	0.000	0.900	-0.00322	0.000	0.045	0.00682	0.000	0.427	-0.04868	0.000	0.553
1988	1998	0.01235	0.000	0.969	-0.00345	0.000	0.045	0.00655	0.000	0.479	-0.04717	0.000	0.494
1989	1999	0.00774	0.000	0.866	-0.00330	0.000	0.038	0.00603	0.000	0.505	-0.04983	0.000	0.451
1990	2000	0.00208	0.000	0.112	-0.00288	0.000	0.028	0.00544	0.000	0.518	-0.04428	0.000	0.357
1991	2001	-0.00565	0.000	0.212	-0.00220	0.000	0.017	0.00472	0.000	0.487	-0.03972	0.000	0.341
1992	2002	-0.00838	0.000	0.430	-0.00144	0.000	0.008	0.00393	0.000	0.408	-0.03380	0.000	0.303
1993	2003	-0.01318	0.000	0.524	-0.00064	0.000	0.002	0.00310	0.000	0.289	-0.03038	0.000	0.288
1994	2004	-0.01545	0.000	0.638	0.00004	0.000	0.000	0.00235	0.000	0.171	-0.02740	0.000	0.254
1995	2005	-0.01758	0.000	0.590	0.00033	0.000	0.001	0.00164	0.000	0.080	-0.01877	0.000	0.148
1996	2006	-0.02079	0.000	0.639	0.00026	0.000	0.001	0.00108	0.000	0.032	-0.01521	0.000	0.115
1997	2007	-0.02281	0.000	0.746	-0.00014	0.000	0.000	0.00056	0.000	0.008	-0.02132	0.000	0.238
1998	2008	-0.02782	0.000	0.786	-0.00086	0.000	0.006	0.00016	0.000	0.001	-0.02483	0.000	0.306
1999	2009	-0.02686	0.000	0.748	-0.00177	0.000	0.025	-0.00008	0.000	0.000	-0.03021	0.000	0.382
2000	2010	-0.02514	0.000	0.547	-0.00266	0.000	0.048	-0.00028	0.000	0.002	-0.02513	0.000	0.313
2001	2011	-0.02006	0.000	0.361	-0.00340	0.000	0.070	-0.00038	0.000	0.003	-0.02220	0.000	0.264
2002	2012	-0.01955	0.000	0.257	-0.00388	0.000	0.083	-0.00036	0.000	0.003	-0.02075	0.000	0.193
2003	2013	-0.01487	0.000	0.311	-0.00407	0.000	0.089	-0.00028	0.000	0.002	-0.01969	0.000	0.180
2004	2014	-0.01344	0.000	0.260	-0.00407	0.000	0.091	-0.00015	0.000	0.000	-0.02148	0.000	0.221
2005	2015	-0.01331	0.000	0.347	-0.00387	0.000	0.088	0.00001	0.000	0.000	-0.03006	0.000	0.323
2006	2016	-0.00892	0.000	0.253	-0.00349	0.000	0.081	0.00014	0.000	0.000	-0.03416	0.000	0.430
2007	2017	-0.00699	0.000	0.113	-0.00307	0.000	0.076	0.00030	0.000	0.002	-0.02407	0.000	0.288

Notes: This table stands for estimation results on ten-year-period piecewise β-convergence estimations on sub-regions from 1960–1970 to 2007–2017 by equation (1). "Coef." stands for estimated convergence coefficient.

Abstract (In Japanese)

要約

本ペーパーは、世界の出生率の収束について 1955～2005 年の 5 年毎のデータで検証した Dorius (2008)を拡張し、1960～2017 年の年次データを用いて世界と地域の出生率の収束を β コンバージェンス・不平等指数・標準偏差の 3 つの角度から分析する。
この結果、1990 年代後半から始まった世界の出生率の収束は 2017 年まで続いていることが示された。
また、本ペーパーは、世界の各地域における出生率の収束を初めて分析したものであり、各地域の 1960 年の平均出生率の水準によって、その後の収束の状況が異なることを明かにした。1960 年の出生率が 6 を下回っていた欧州、東アジア・太平洋、中央アジア、及びアメリカ大陸ではここ数十年出生率の収束がみられる。これに対して、1960 年の出生率が 6 を上回っていた中東・北アフリカ、サブサハラ・アフリカ、及び南アジアでは、出生率の収束は今のところ観察されない。この結果は、本研究のもう一つの成果である 1960 年の出生率が 5.8 以下のサンプルで推計した場合に β-コンバージェンスは最も統計的有意性が高まるとの結果とも整合的である。

キーワード：人口、合計特殊出生率、世界、地域、収束

JICA Research Institute

Working Papers from the same research project

"Research on Declining Fertility in East Asia"

JICA-RI Working Paper No. 165

Inverse J-Shaped Relationship between Fertility and Gender Equality: Different Relationships of the Two Variables According to Income Levels

Yoko Nakagaki